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OCTOBER 2001

NATIONAL GEOGRAPHIC

TRACKING THE LEOPARD


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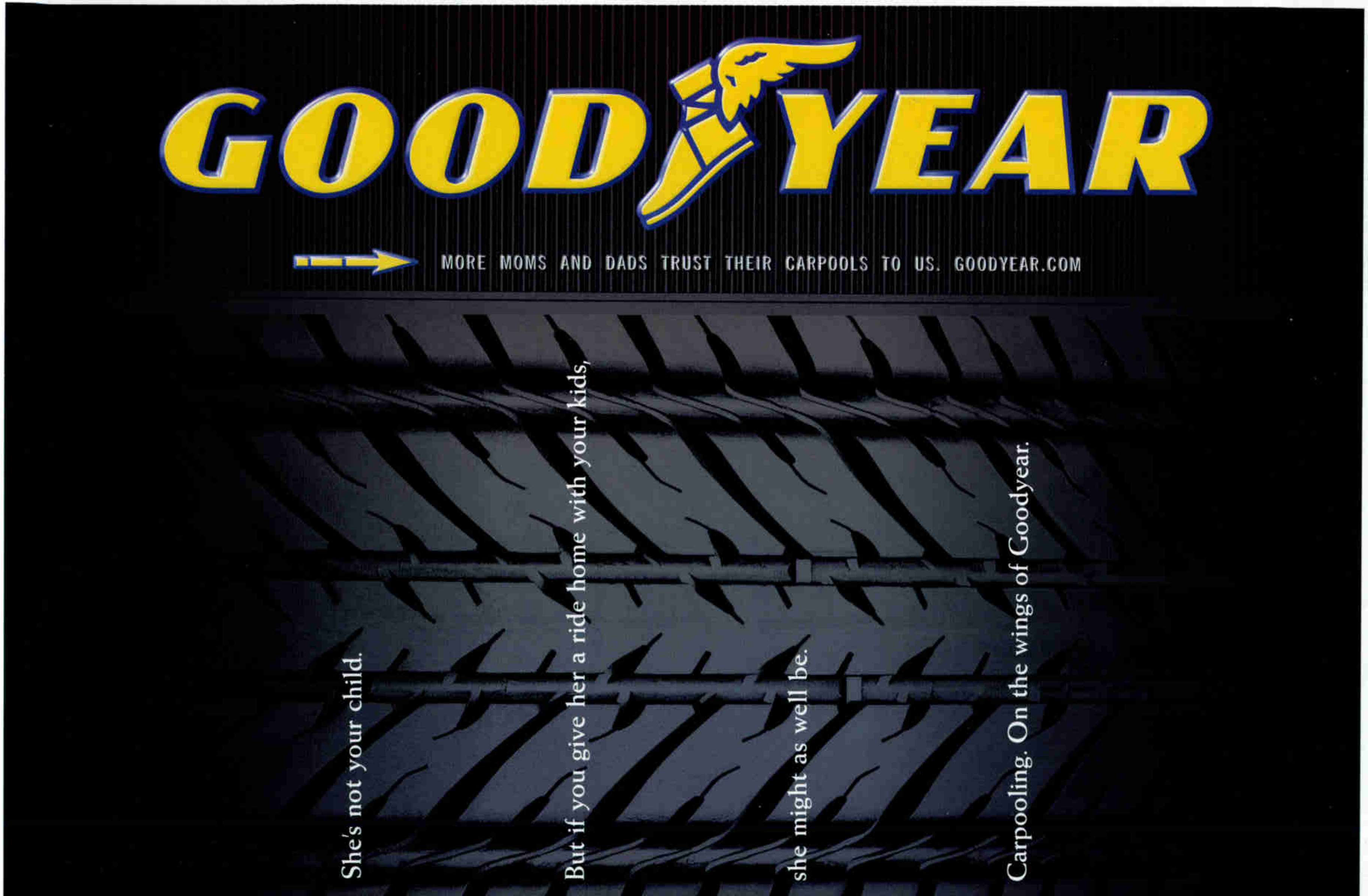
GOODYEAR
MORE MOMS AND DADS TRUST THEIR CARPOOLS TO US. GOODYEAR.COM
She's not your child.
But if you give her a ride home with your kids,
she might as well be.
Carpooling. On the wings of Goodyear.

It's not often a two-hour ride lasts a lifetime.

Talk to most motorcyclists, and they'll tell you how one ride can get inside you, and stay with you forever. This same phenomenon happens on another level at every *Ride for Kids*® event. Each ride works to improve the lives of kids who have been diagnosed with childhood brain tumors by raising funds for medical research.

Our progress is encouraging. In 1984, a child diagnosed with a brain tumor was expected to live only five more months. Today, medical advancements allow that child to live another three years.

With Honda's support, more than 10,000 motorcyclists devote their time, money and energy to the *Ride for Kids* program every year. Yet everyone's goal of finding the cause of childhood brain tumors, and discovering a cure, remains many rides away. Which is why Honda continues to nurture this program. Because, while the ride lasts only a day, it leaves us with hope that lasts a lifetime.

HONDA

The power of dreams.™

Pictured: Juston Smart and his dad, Jeff. Juston is a brain-tumor survivor and supporter of the *Ride for Kids* program. For more information, call the Pediatric Brain Tumor Foundation of the United States at 1-800-253-6530, or visit pbtfus.org.

VOL. 200 • NO. 4 • OCTOBER 2001

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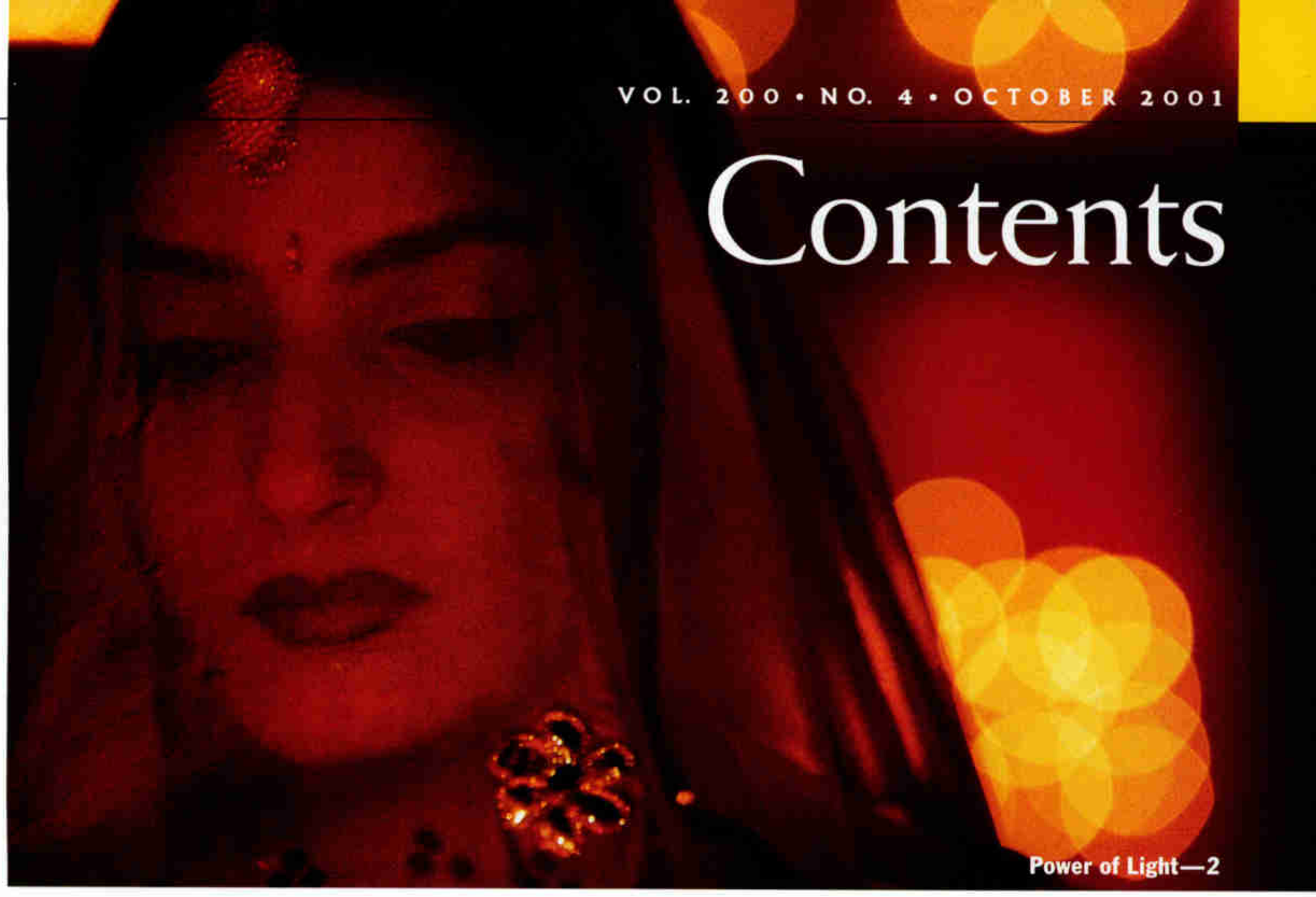


Power of Light—2

FEATURES

DEPARTMENTS

THE COVER

Tjololo struts through South Africa's Mala Mala Game Reserve. The 150-pound cat can lift prey twice its weight into the treetops.
BY KIM WOLHUTER

Cover printed on recycled-content paper

ON THE NGM WEBSITE

nationalgeographic.com/ngm/0110

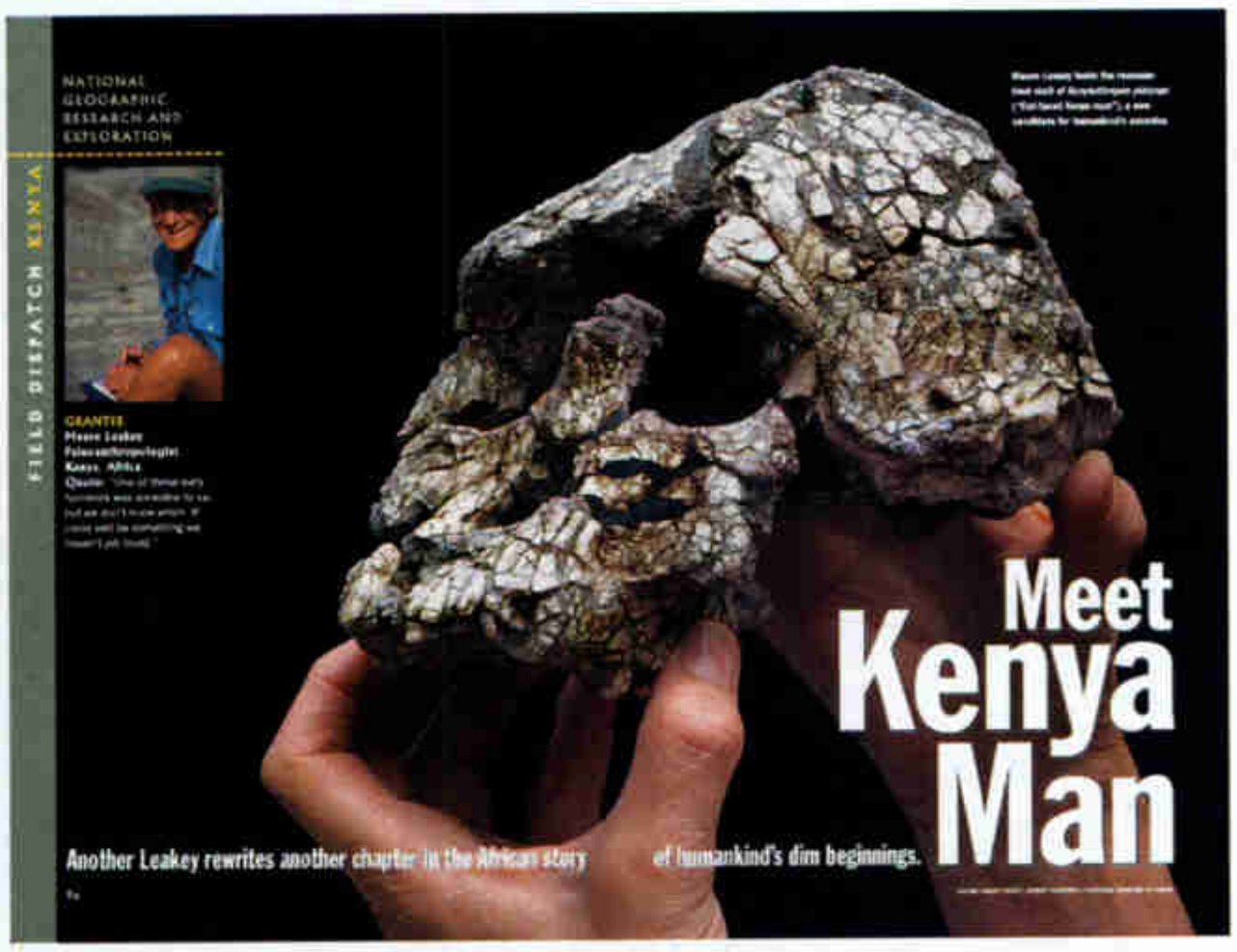
SIGHTS & SOUNDS How do you photograph the power of light? Learn techniques for capturing the intangible.

HOMINID FIND Meave Leakey responds to your questions.

RAIN FOREST Watch the creatures that come out at night.

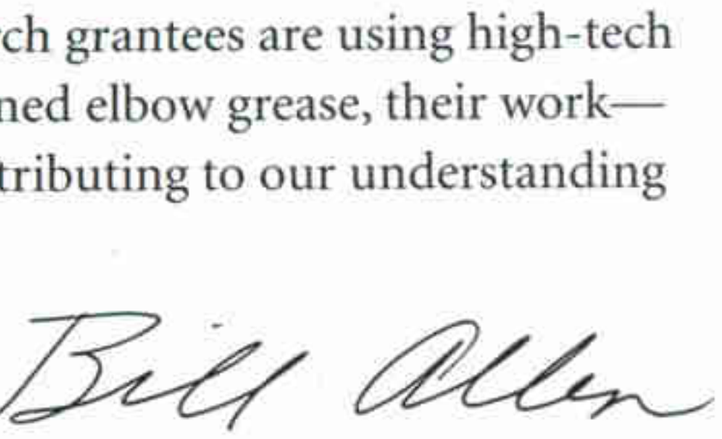
FORUMS Share your opinions.

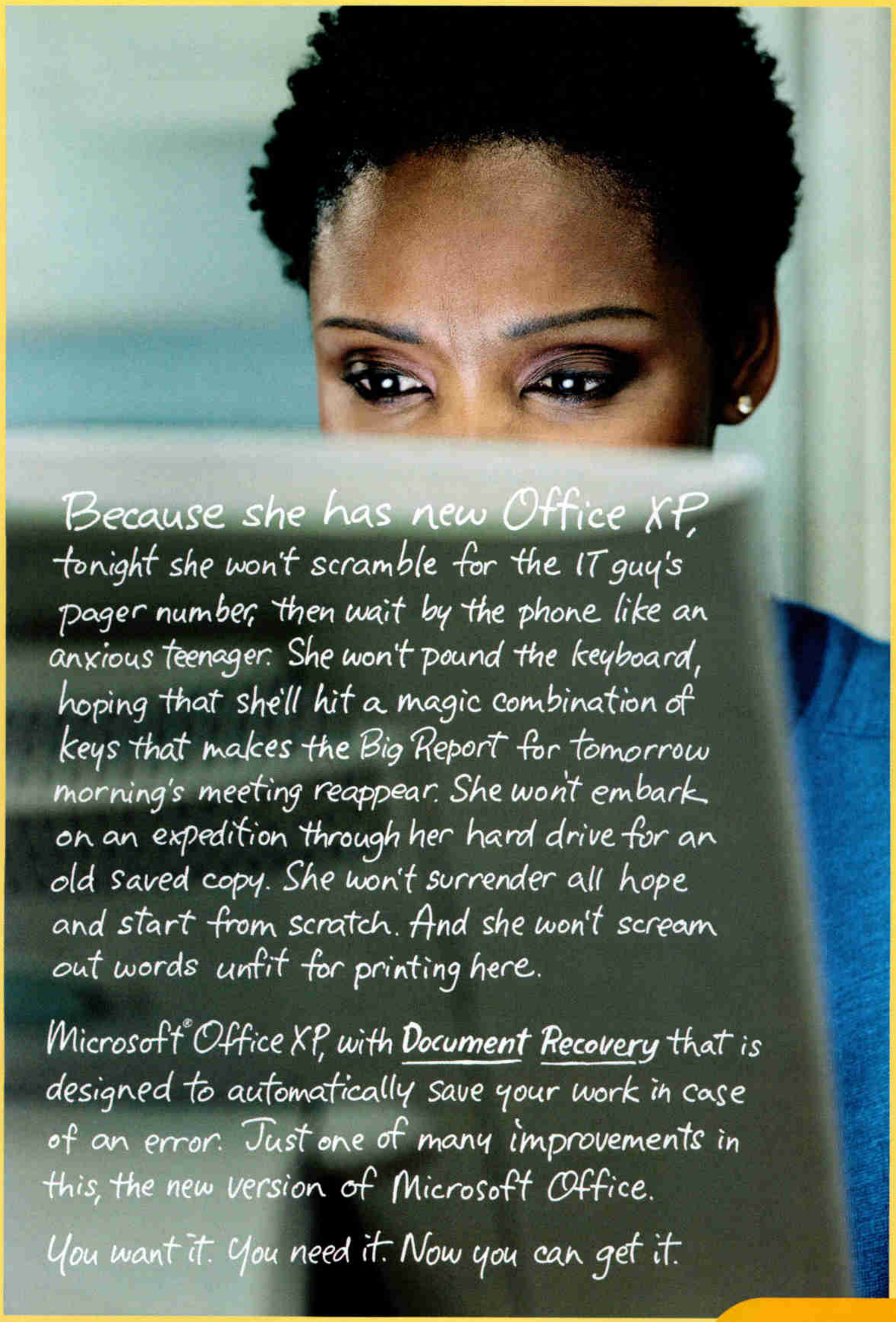
From the Editor



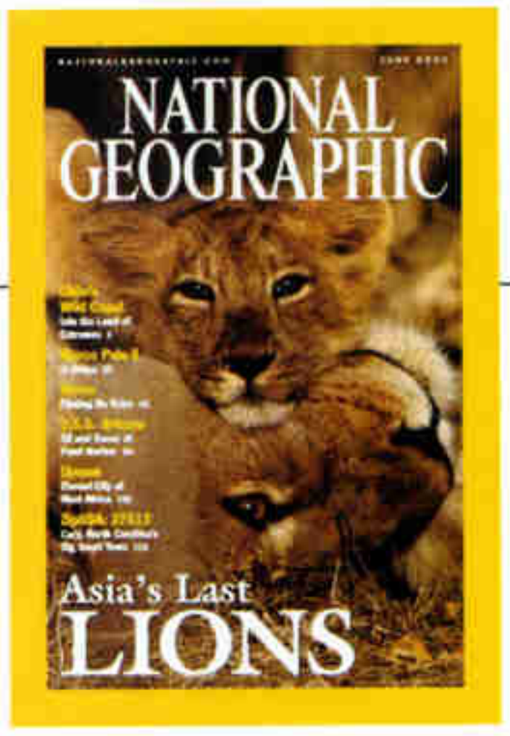
For more than 40 years the National Geographic Society has helped fund the Leakey family and their teams as they search for clues to the origin of the human species. This month the latest endeavor of Meave Leakey begins a new series—*Field Dispatches*—highlighting the work of our Committee for Research and Exploration grantees. The Society has awarded over 7,000 such grants, made only after extensive review of the proposals' scientific merit by a distinguished panel of scientists. Only a small number of these projects can be featured in major NATIONAL GEOGRAPHIC articles. You the members, whose dues support the researchers, don't see most of the fruits of their labors. *Field Dispatches* will let you share in the discoveries of at least a few more.

Last month in our article "How Old Is It?" we explained a fundamental element for understanding many scientific fields, including Meave Leakey's field of paleoanthropology. The article detailed the techniques used to establish the age of the universe, of earthly plant and animal fossils, even of Antarctic ice. Yet whether our research grantees are using high-tech instruments or old-fashioned elbow grease, their work—and your support—is contributing to our understanding of the world.





Forum



June 2001

Though decades have passed and other wars have been fought, passions about Pearl Harbor remain strong. The U.S.S. Arizona*'s leaking oil has sparked a new battle in the Pacific. "Are we waiting for another Pearl Harbor to happen on a disastrous environmental scale?" asked a reader. Even if oil "blackens all of Pearl Harbor," wrote another, "let it remind us of the blood of those who died."*

Pearl Harbor

I find it hard to understand that no effort is being made to drain the oil contained in the U.S.S. *Arizona*. I truly believe this issue goes beyond nationalism. The fact that it damages marine life and threatens an ecosystem is reason enough to start efforts on this matter.

LUIS JAVIER UREÑA
Monterrey, Mexico

The National Park Service is studying how to remove the oil without collapsing the hull, which is expected to hold for about another 50 years.

Leave the *Arizona* and her crew alone. This isn't science. It's curiosity and no better than ripping a grave apart to see if the coffin is intact and what condition the body is in. We don't need to outrage the dead sailors by invading their last resting place.

WARREN BOSLEY
Grand Island, Nebraska

I was a teenager during World War II, but I remember one of the Japanese midget submarines that was used to sell war bonds and war savings stamps across the country. It came to nearby Bethlehem, Pennsylvania, on a flatbed trailer. One side had the metal removed about a foot high on the entire length of the sub. When you purchased a bond or stamp, you could examine the inside. I bought stamps, and when I got to the conning tower area, I saw a mannequin of a Japanese officer by the periscope. It was so real that it scared the hell out of me.

RICHARD L. KANTOR
Hellertown, Pennsylvania

My brother, Lt. Phillip Willis, was in charge of a patrol that sighted the small submarine lodged on a reef following the attack on Pearl Harbor. One of the two crewmen had drowned, so they took the other member ashore and then to Bellows Field. The Japanese crewman asked to be killed, for he had disgraced the emperor, and my brother said some of the GIs wanted to accommodate him, but he was interrogated and sent to a prisoner of war camp.

DOYLE WILLIS
Fort Worth, Texas

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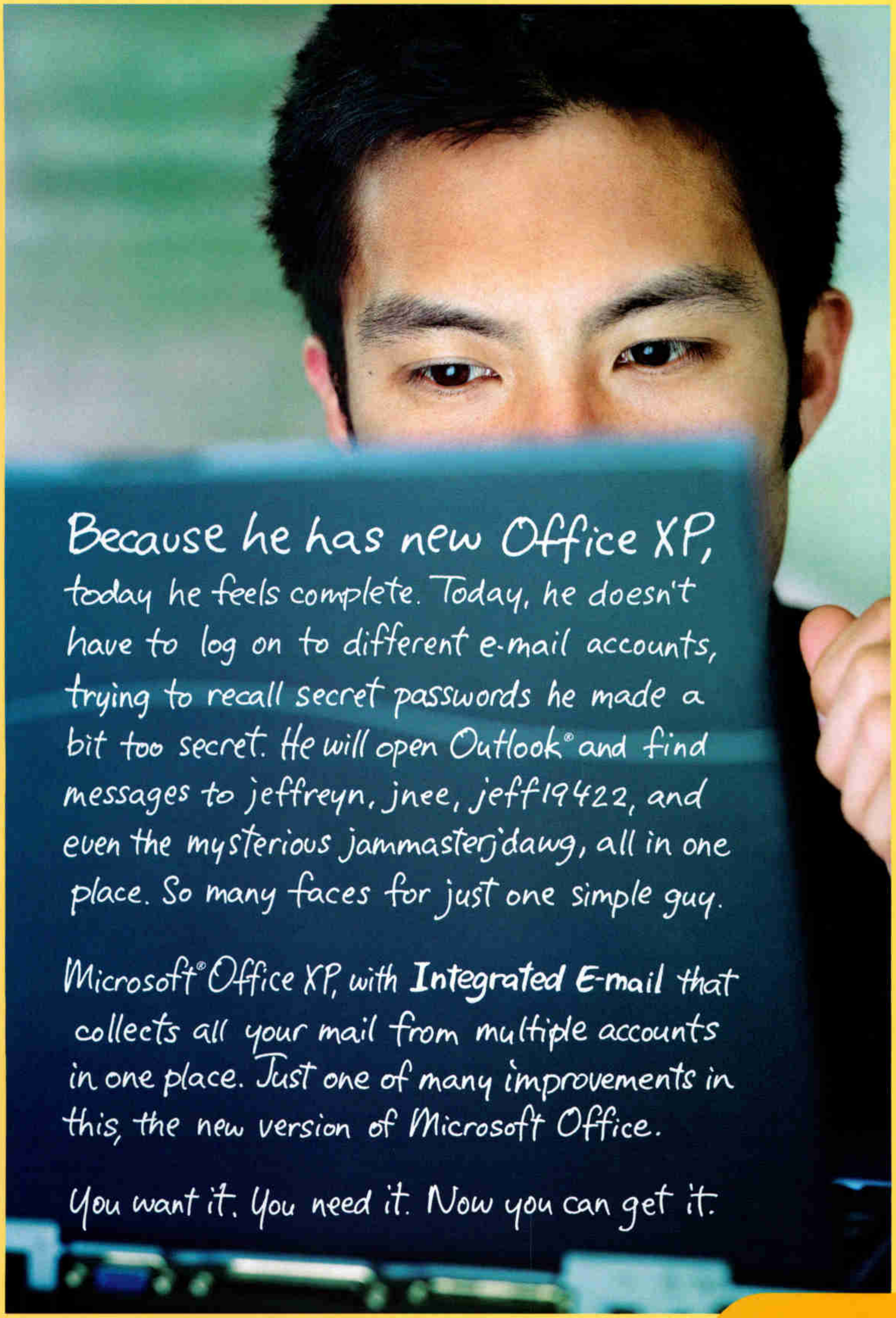

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MICHAEL YAMASHITA

Marco Polo II

While the travels of Marco still fascinate us in the West, it is less well-known that at virtually the same time a Christian monk, Rabban Sauma, traveled west from China into Europe. About 1275 he left for Jerusalem but turned instead toward Constantinople and Europe. He was received in Paris by Philip the Fair, the young king of France, and later in Bordeaux by King Edward I of England. He also met with the pope in Rome. Marco and Rabban Sauma may well have crossed paths.

GLENN DIXON
Calgary, Alberta

More on Rabban Sauma's journey appears in the Did You Know? feature for Marco Polo II on our website (nationalgeographic.com/ngm/0106).

I am bothered by the caption for the photograph on pages 40-41 (above), "women . . . sit down to gossip." You perpetuate the myth that when women get together it is for vile, petty talk. My chatting time with female friends is spent bouncing around ideas about raising a family and sharing triumphs and tribulations. It is the stuff of life.

ANNE H. WATSON
Arlington, Virginia

Last month I went on a tour of Central Asia. It was suggested that we take gifts for local residents. After racking my brain to think of something useful besides stickers, pens, or candy, I hit upon the idea of redistributing my old NATIONAL GEOGRAPHICS. I took about 20, which weighed a ton, but people were thrilled to have them. Also several people in Uzbekistan told me that they received the National Geographic Channel as one of five channels available there.

CHERI HUNTER
Pacific Palisades, California

I was disappointed that your article refers only to Japanese historians who say the attack was because Japan could not accept the U.S. oil embargo "without deep humiliation and was left no alternative." You omit the reasons for the embargo. Japan had waged war against China and occupied its lands. It had designs on much of Asia. The U.S. embargoed oil to discourage war and encourage peace. The insatiable aggression of Japan's military-industrial complex was the reason for the attack, not honor and saving face.

KIRKWOOD M. CALLAHAN
Whittier, North Carolina

Mitsuo Fuchida was the leader of the first wave of Japanese pilots who devastated the United States Navy. He was the one who broadcast the message "Tora, tora, tora," indicating that surprise had been achieved. I had the opportunity to meet him in the 1960s when he came to speak at a church my family was attending in Garden Grove, California. Fuchida had become a Christian missionary, quite a change from 20 years before. I was only a lad at the time, but it is something I will never forget.

KEVIN NEWMAN
Chesterfield, Virginia

Celtic Wales is the Estonia of Western Europe. We are a nation of just three million souls who share a border with a people who built the largest empire in history and whose language has become the lingua franca of the world. Yet we who live in the Welsh-speaking rural heartland are not "conservative and inward-looking." We perceive the world from a uniquely Welsh perspective; the so-called cosmopolitan outlook of our anglicized brethren is based on an erroneous supposition that equates Anglo-Americanism with internationalism.

RHOBERT AP STEFFAN
Llangadog, Wales

WRITE TO FORUM

National Geographic Magazine, PO Box 98198, Washington, DC 20090-8198, or by fax to **202-828-5460,** or via the Internet to **ngsforum@nationalgeographic.com.** Include name, address, and daytime telephone. Letters may be edited for clarity and space.

Wales

North Americans and many Europeans refer to Britain and England as if they were synonymous. I am glad NATIONAL GEOGRAPHIC clarified the existence of the original Britons as being *yma o hyd*—still here.

Your article took me back to 1960 when I worked as a trainee with the Steel Company of Wales. When I mentioned to my English friends that I was going to be in Wales for some time, many expressed sympathy for

Biotechnology researchers call it "golden" rice.

For the color.
For the opportunity.

"When mothers and their children eat an adequate amount of vitamin A in a daily meal, it could help alleviate more suffering and illness than any single medicine has done."

The excitement expressed by plant biologist Charles Arntzen reflects the golden opportunity that many see in a new strain of rice being developed with biotechnology. "Golden" rice contains increased amounts of beta-carotene, a source of vitamin A. Because rice is a crop eaten by almost half the world, golden rice could help relieve a global vitamin A deficiency that now causes blindness and infection in millions of the world's children.

Discoveries in biotechnology, from medicine to agriculture, are helping doctors treat our sick, farmers protect our crops – and could help mothers nourish our children, and keep them healthier. To learn more about biotechnology and agriculture, visit our Web site or call us.

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the things I would have to put up with there. But I found the Welsh to be warm and friendly. As a young man from India, which had just gained independence from British rule in 1947, I seemed to touch a chord in them. They invited me to their homes, ribbed me mercilessly, took me to cricket matches as well as to church choirs. The Welsh have a great sense of humor and make fun of everything, including themselves. Thank you for profiling a truly great people in your inimitable style.

J. RENGARAJAN
Chennai, India

You ignored Charlotte Church, the most talented star to come out of Wales in recent history. She is single-handedly revitalizing classical music.

RON FITZSIMMONS
Edmonton, Alberta

I noticed the map of Wales included the little railway stop on the island of Anglesey, Llanfairpwllgwyngyllgogerychwyrndrobwllllantysiliogogogoch. People might be interested to know that it means the "church of St. Mary in the hollow of the white hazel near the rapid whirlpool and the church of St. Tysilio by the red cave."

MARVIN O. ROWLAND
Titusville, Florida

Djénné

I was fortunate enough to spend some time in Djénné several years ago, and there really is an old, magical feeling there, like the roots go down forever. I remember sleeping on a rooftop and being awakened by a huge sandstorm and thinking, This could be anytime, a thousand years ago. It's a powerful, extreme land that shapes that place and an equally powerful heart and skill in the people that make Djénné endure.

TIM GITTINGS
Forest Park, Illinois

There really is an old, magical feeling there, like the roots go down forever. I remember sleeping on a rooftop and being awakened by a huge sandstorm and thinking, This could be anytime, a thousand years ago.

As an architectural student I was saddened to read that a condition of the Netherlands' grant to restore 168 dwellings is that residents must agree to keep their houses traditional. Imagine if it had been decided that Western architecture attained perfection in the Renaissance. We never would have had the baroque or the 20th-century skyscraper. Djénné is a living city that needs room to evolve and adjust to changing needs.

DREW LEIGH PEARMAN
Werribee, Australia

ZipUSA: Cary, North Carolina

Cary, along with hundreds of other virtually identical suburbs, represents the suburban sprawl that has gobbled up the nation's farm and forest land. It is this sort of shortsighted and poorly planned development that is damaging the environment while adding to traffic congestion and increased commuting times. In addition the cookie-cutter houses create bleak neighborhoods devoid of any individualism. I guess the American dream now includes a two-hour commute, strip malls, and a willingness to conform to your neighbors, even if you don't know them.

ARVIND VISWANATH
Columbia, Missouri

I am pained by the lack of recognition given to Cary's working-class community. Many of these people are restricted by high property values to mobile-home parks, which your article failed to mention.

JOHN RING
Cary, North Carolina

Geographica

Earlier this year 14 Mexicans found a terrible death when crossing the Arizona desert. They were looking for work not available in Mexico. The development of Xcacel could provide several thousand badly needed jobs.

JAIME DELGADO
Cancún, Mexico

I think it is extremely important that Mexico's Caribbean coast be protected. I was born in Fiji and lived there for most of my life. We have turtles that are becoming extinct. Our government has not done much about it, as turtles are a local delicacy. Each year when I go back for the holidays, I see more of these beautiful creatures slaughtered in the markets. If this continues, there will be nothing left for my children to see.

EDWINA HARM NAM
Auckland, New Zealand

DID SHE CAST A SPELL ON THE FOREST?

As a girl, the story of *Tarzan*® stirred her imagination. As a young woman, she ventured into the wilds of Africa to study chimpanzees. And proceeded to lay the foundation for all future primate research. Her name is Jane Goodall. She's dedicated her life to all living things. Founded the Jane Goodall Institute, which supports programs in wildlife research, conservation, education and animal welfare. And spends her days working with young people around the globe. Dr. Jane Goodall, naturalist, is one of Ford Motor Company's Heroes for the Planet. A program that's part of ongoing Ford Motor Company initiatives to underwrite and support efforts that make the world a better place. To learn more about Dr. Goodall and other Heroes for the Planet, visit our website. You'll find fascinating information, including links to her favorite websites. Around the globe, there are amazing individuals who've dedicated their lives to our planet. You'll find them at www.ford.com/heroes. Stop by. The world is waiting.

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EarthPulse

WILD SPECIES

Paving the Road to Extinction

Signs warn of humankind's acceleration of species loss

Millions of plants and animals disappeared during five great mass extinctions between 440 and 65 million years ago. Since then humans have colonized continents and islands throughout the world. Their actions, such as destruction of habitat and overhunting, have dramatically increased extinctions. Before the arrival of humans, natural losses, caused by factors such as climate change, averaged roughly one species per million each year. That rate is now perhaps 10,000 times higher—what experts in the field consider an ongoing sixth mass extinction, largely due to human influences.

Since A.D. 1500, out of 51,000 vertebrate species, 337 have become extinct. An estimated 27,000 species of all kinds, predominantly insects and plants, disappear each year in rain forests alone. Worldwide, pollution and the introduction of non-native species also take a rising toll.

Danger Ahead

More than 11,000 plant and animal species face extinction in the near future, says the International Union for the Conservation of Nature. The IUCN study, which assessed less than 0.1 percent of known insect species, states that a quarter of all mammal species and an eighth of all bird varieties, including the rarest in the wild—Spix's macaw (above)—are at risk. Since 1996 the number of critically endangered primate species has grown from 13 to 19.

1900s

● **Passenger pigeon:** Probably the most abundant bird on Earth in the 19th century, millions in the eastern U.S. were slaughtered for food by commercial hunters. The last known passenger pigeon died in captivity in 1914.

1920-1950

● **Pig-footed bandicoot:** These small marsupials ranged southwest-central Australia. They lost habitat to ranchers and were attacked by foxes and feral cats brought by Europeans. No one has seen the bandicoot since the 1950s.

Where Are the Greatest Losses?

Highlighting global trouble spots, this terrestrial ecoregion map, based on World Wildlife Fund and IUCN data, compares bird and mammal species at risk around the world. With high human populations and consequent habitat loss, Brazil, Indonesia, and China have the most species at risk. Since the last global assessment by the IUCN in 1996, the number of known threatened animal species has risen from 5,205 to 5,435.

Threatened bird and mammal species
- 46-65
- 20-45
- 0-19

NG MAPS

1950-1970

● **Caribbean monk seal:** "Sea wolves," likely monk seals, were killed by Columbus's crew in 1494. Hunting increased, and none have been seen since 1952. Other monk seal species survive in the Pacific and Mediterranean.

1970-1990

● **Javan tiger:** One of eight original subspecies of tigers, these lost habitat to deforestation on the Indonesian island of Java, becoming extinct some 20 years ago. The critically endangered South China tiger may be next.

1990-2000

● **Miss Waldron's red colobus:** These 20-pound monkeys lived in Côte d'Ivoire and Ghana. Their extinction, documented last year, was the first among primates in 200 years. Hunting and habitat loss doomed them.

Get Involved

For more information:

2000 IUCN Red List of Threatened Species
redlist.org

Committee on Recently Extinct Organisms
creo.amnh.org

SOURCE: JOHN LAMOREUX AND DAVID OLSON, WORLD WILDLIFE FUND; IUCN RED LIST 2000. ART: TOBY WELLES

The deadliest creature in the rain forest
is not threatening if

handled properly

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Tourism can be a boon to an economy, but it can be a bust if it destroys the environment. That's why Ford Motor Company partnered with Conservation International and others to create a walkway that helps preserve part of the Brazilian Atlantic rain forest and lets visitors experience this rich ecosystem. The income from ecotourism offers an alternative to a destructive logging-based economy.

Ford Environmental Steward Luis Lara wants people to see the rain forest, but more than that, he wants a rain forest left for people to see.

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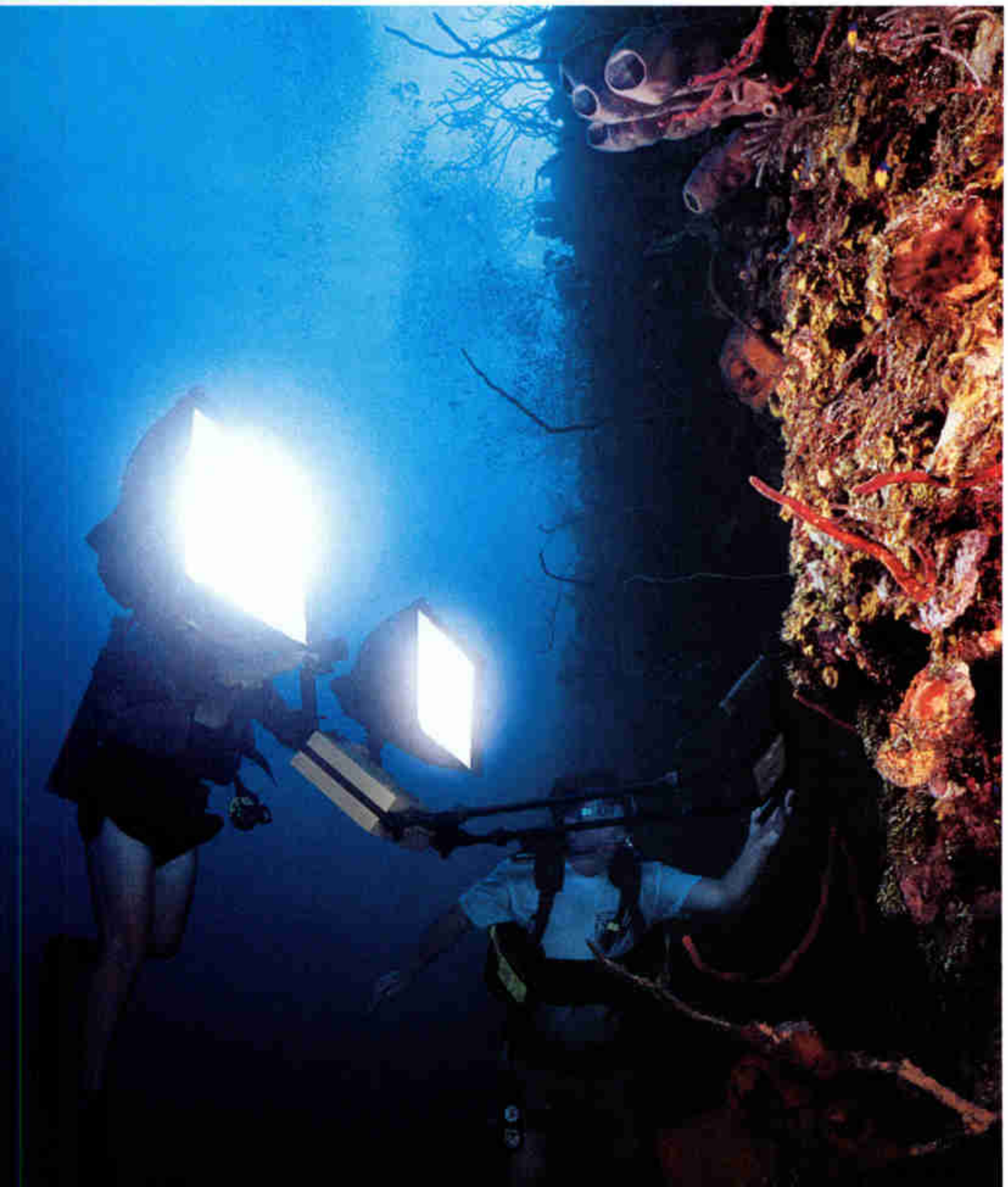
THE PEOPLE, PLACES, AND



MARINE LIFE

Portrait of a Coral Reef

Photographic innovation allows wide-view image

Coral reefs that grow to form a large wall have always been magnets for scuba divers. Making wide-view images of those reefs, such as renowned Bloody Bay Wall off Little Cayman Island in the British West Indies, has been a challenge for professional photographers. At even moderate depths in good-quality water, clarity fades beyond a few feet using traditional underwater lights. "Also, most of the color spectrum except blues and greens is absorbed," says San Diego photographer Jim Hellemn, who eventually solved the problem.

APHICA

Using new lighting, digital imaging, and photographic techniques, Hellemn created the Bloody Bay Wall mural (top), which he stitched together from 280 individual frames in 14 months. He can produce the mosaic life-size, about 70 feet long by 20 feet high. While making a frame, Hellemn (left) manipulates the camera system's lights and wide-area diffusers to cover a 48-by-36-inch area with soft, even light.

He also can highlight details. A two-foot-long hawksbill turtle (above) swims past a cave at center left in the main image. Four eighteen-inch-long tube sponges protrude at far right in the mural, below two larger ones.

How else might the technique be used? "It could help study changes in a reef over time," Hellemn says. "While we were photographing the reef, I noticed a large section of sheet corals, some of them two feet in diameter. Several months later we went back and found that three-fourths of that coral cluster had apparently dropped off the reef wall." Perhaps marine biologists studying coral reefs around the world will take note.

PETER NEUBAUER (BOTTOM LEFT); JIM HELLEMN

THE MAIZE LLC

AGRICULTURE

If You Build It, They Will Come

Cornfield mazes are a growing trend

American farmers are finding a new way to make more money off their feed-corn crops: getting people lost. Last year thousands of visitors to "maize mazes" paid $5 to $10 each to wander through the corn. This year farms in more than 40 states will boast mazes, most of which are custom-planned—often with state-specific themes (above)—by private companies. The secret of the mazes? Most designs are computer-drafted on a grid, then paths are tilled in the field when the corn is tender and short. The crop is tended as usual. As the plants grow, so do farmers' profits.

ALMANAC

October

Female northern right whales teach their calves to swim in the heaving Bay of Fundy off Nova Scotia until the end of October. Perhaps the bay's 53-foot tides and fogbanks kept whalers from hunting the species there. The waters are rich, but the youngsters must learn to dive deep for food. The species numbers only 300.

ART BY SHAWN GOULD

AUBREY VINCENT BEARDSLEY

MEDICINE

Nothing to Sneeze At

Having a black cat around may be bad luck after all—for those with allergies. Researchers at Long Island College Hospital have found that allergy sufferers with dark-furred cats at home reported two to four times more, and worse, symptoms than sufferers with no cats. Cat owners who allowed the animals into their bedrooms reported 19 times more symptoms. There was no statistically significant difference between patients with no cats and light-furred cats.

"I don't know why the dark cats are a problem," says Dr. Shahzad Hussain, who directed the study. "It could be that they produce more sebum, which produces more of the antigens that make you sneeze." Though few allergy sufferers are willing to get rid of their pets, he says symptoms can be greatly reduced by bathing cats weekly and by keeping them away from bedrooms.

UPDATE

For Sale: Animal Parts

Fetish markets in West Africa traffic in wildlife

Lion skulls, chimpanzee heads and hands, and antelope hides, hooves, and horns sit rotting in the sun in the block-long market of Cotonou, Benin (right). Parts of crocodiles and hyenas lie near bats and lizards, including these chameleons (top). Such West African fetish markets "provide a nice sampling of the region's biodiversity, but it's all dead," says Texas A&M biologist Kirk Winemiller.

The dried animal matter is purchased to go into medicines and to be used in rituals, according to some of Winemiller's African colleagues. Said one, "When you need medicine, you go to a pharmacy. This is our pharmacy."

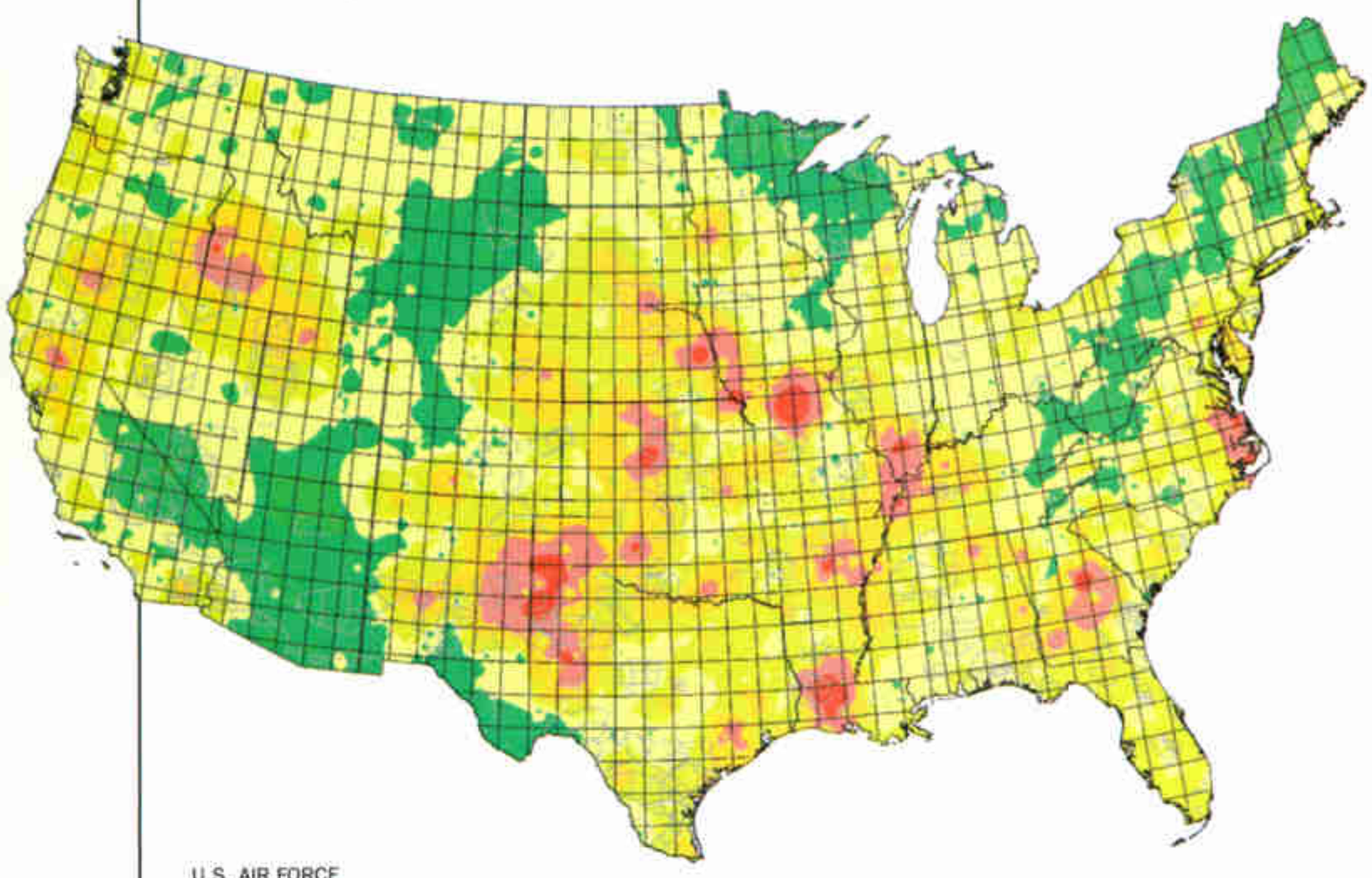
BOTH BY KIRK WINEMILLER

TECHNOLOGY

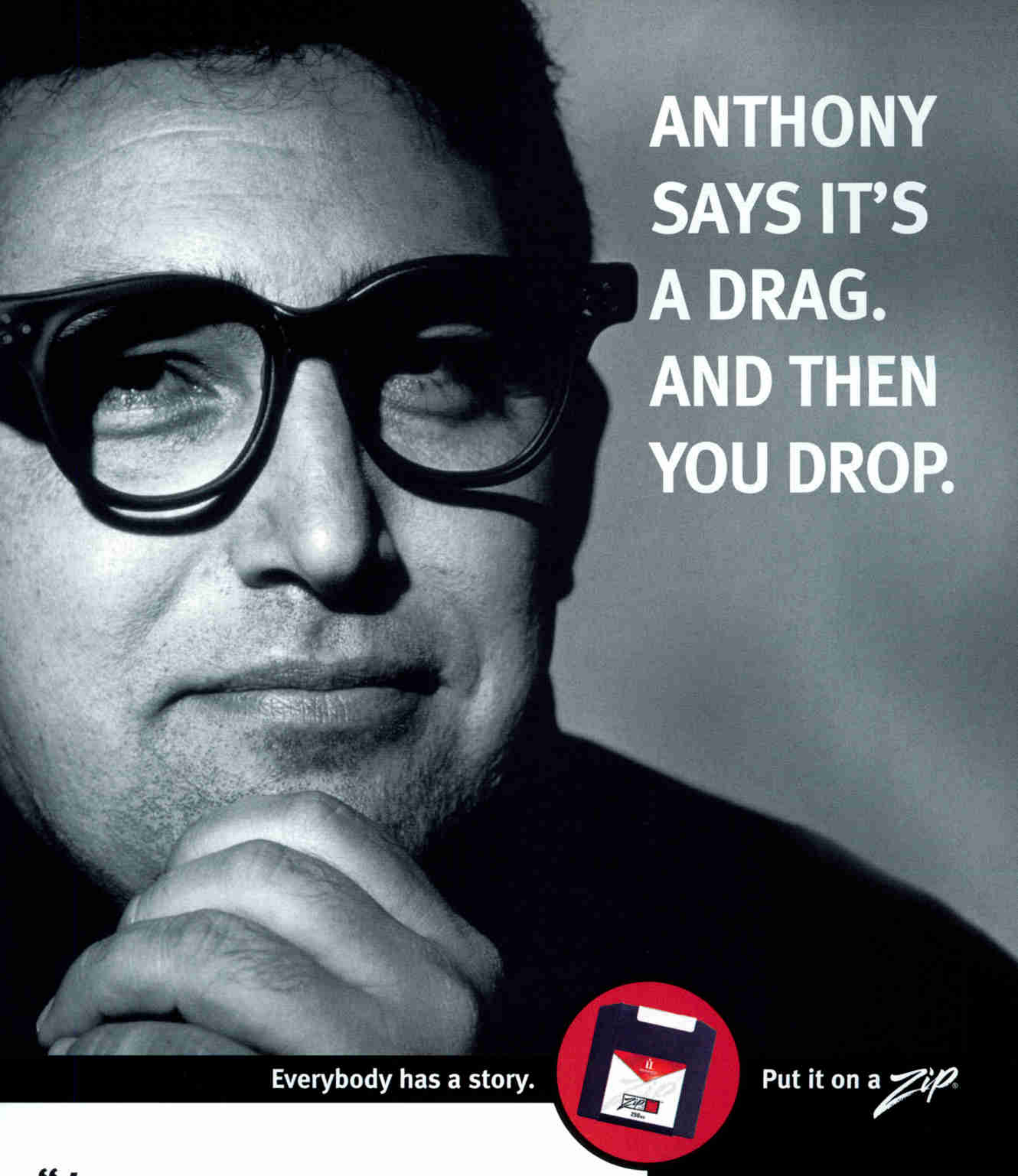
It's a Bird, It's a Plane, It's Trouble

Birds strike aircraft like feathered bombs or bullets. In aviation history more than 400 people have died in such accidents. In the U. S. nearly 9,000 bird strikes were reported on Air Force and civil aircraft in 2000. Having received 38,000 hits since 1985 that killed 33 aviators, the Air Force has developed the Bird Avoidance Model (BAM) to identify seasonal high-risk zones. Showing the highest strike density in red, this map is based on data from late October and early November, when birds of prey and other species migrate.

"BAM can be used months in advance to help plan a mission to avoid high-risk areas," says Lt. Col. Russell DeFusco, who helped to develop BAM. "Or individual pilots can use it the day of their flight to check the risks."



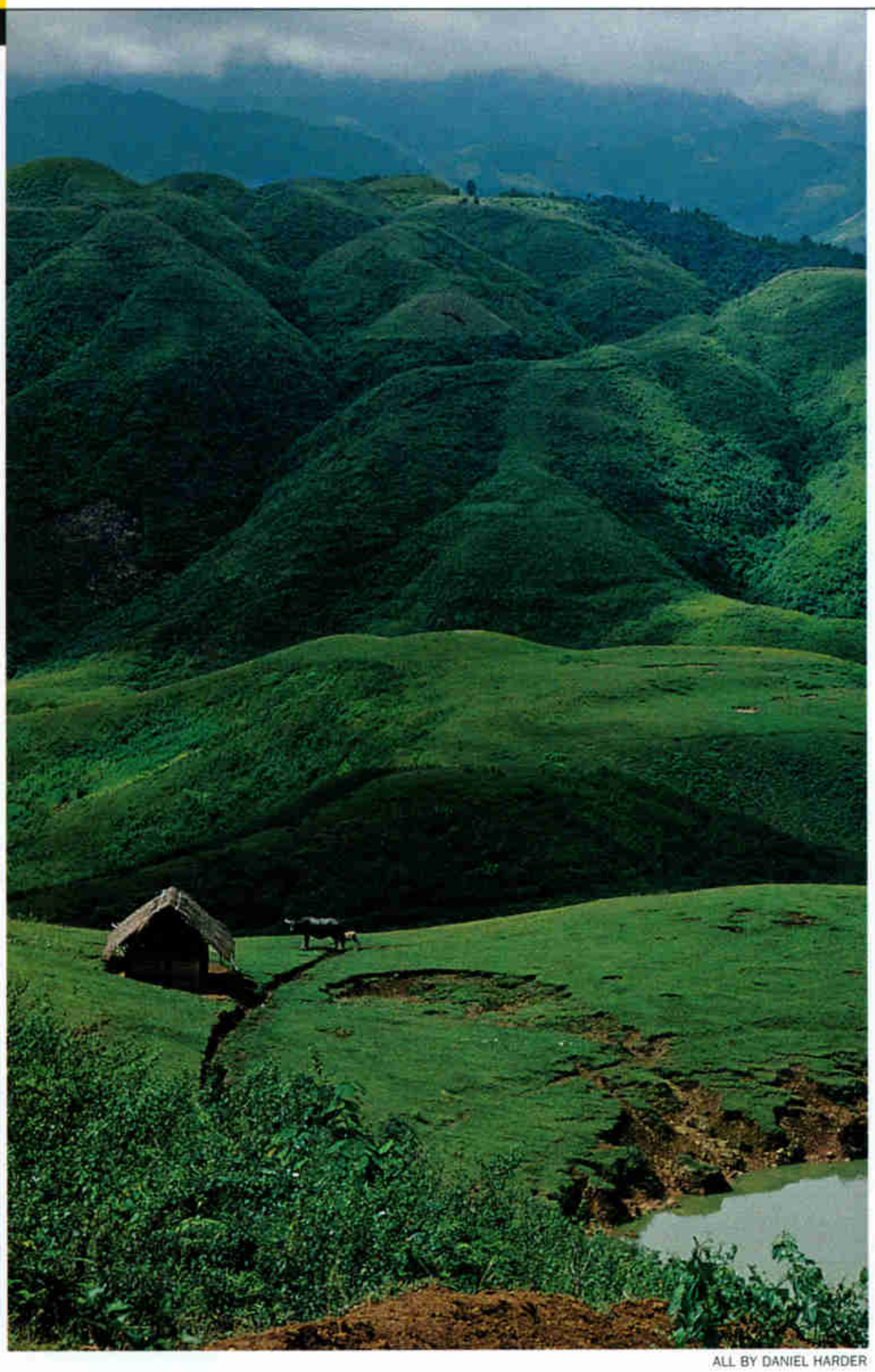
U.S. AIR FORCE



"I was trying to save my personal financial files on my computer by burning the info on a CD, but there always seemed to be a glitch — the CD would get scratched or an error would pop up while it was writing. It was taking forever. I wanted these files to be safe, so I got a Zip® drive. Now I just drag and drop my files into the Zip® icon on my desktop, and it's saved on a Zip® disk. I sure wish filing my taxes was this easy!"

iomega

Download free software at www.iomega.com to see what Zip® can do for you.



ALL BY DANIEL HARDER

LITHOCARPUS ANNAMENSIS

SPATHOGLOTTIS PUBESCENS

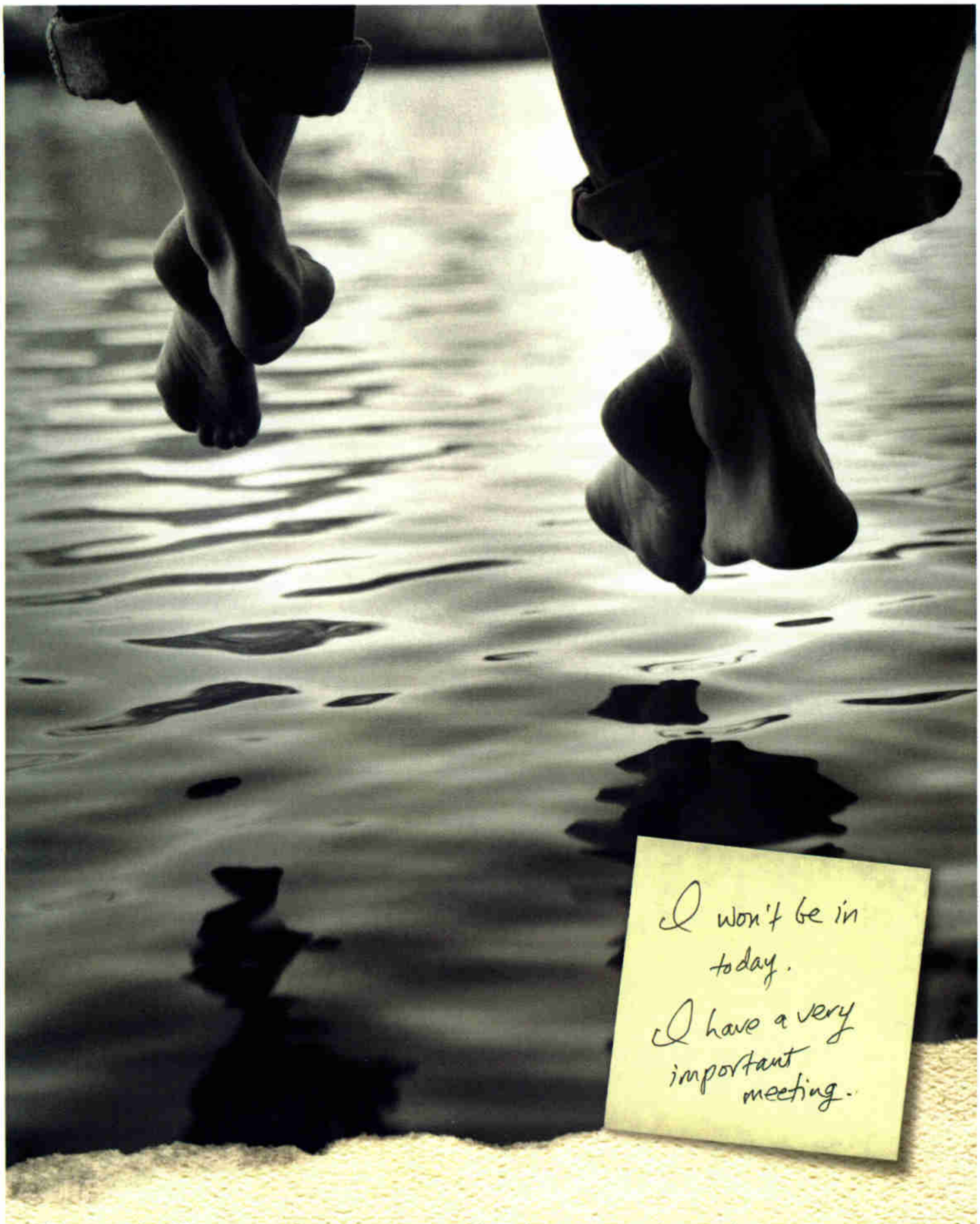
NGS RESEARCH GRANT

Of Growing Interest

Botanical discoveries in northwestern Vietnam

No scientist had inventoried the plant life of the northwestern highlands of Vietnam before Society grantees Daniel Harder, Nguyen Tien Hiep, and Leonid Averyanov got there. "The area had always been pretty inaccessible," says Harder, a Missouri Botanical Garden curator, "and now it's almost all been deforested." The region's slopes (above) host a surprising variety of plants, from oaks (top right) to orchids (center). The team has found a new genus of conifer and several rare lady's slipper orchids, including the one at right, all of which now get some protection. "The market for these orchids is huge," Harder says. "People will dig them up and sell them for hundreds of dollars a plant." As a first step toward preservation, "It was important for us to document what was there."

PAPHIOPEDILUM DIANTHUM



This year, families across the country are making river conservation a priority.
And whether in class, outdoors, or online, National Geographic's education outreach program, *Geography Action! Rivers 2001*, helps bring conservation closer to home. See how your whole family can take action for our rivers at www.nationalgeographic.com/geographyaction.

Rivers...the course our future takes.

NATIONAL GEOGRAPHIC SOCIETY
GEOGRAPHY ACTION! Rivers 2001

www.nationalgeographic.com/geographyaction

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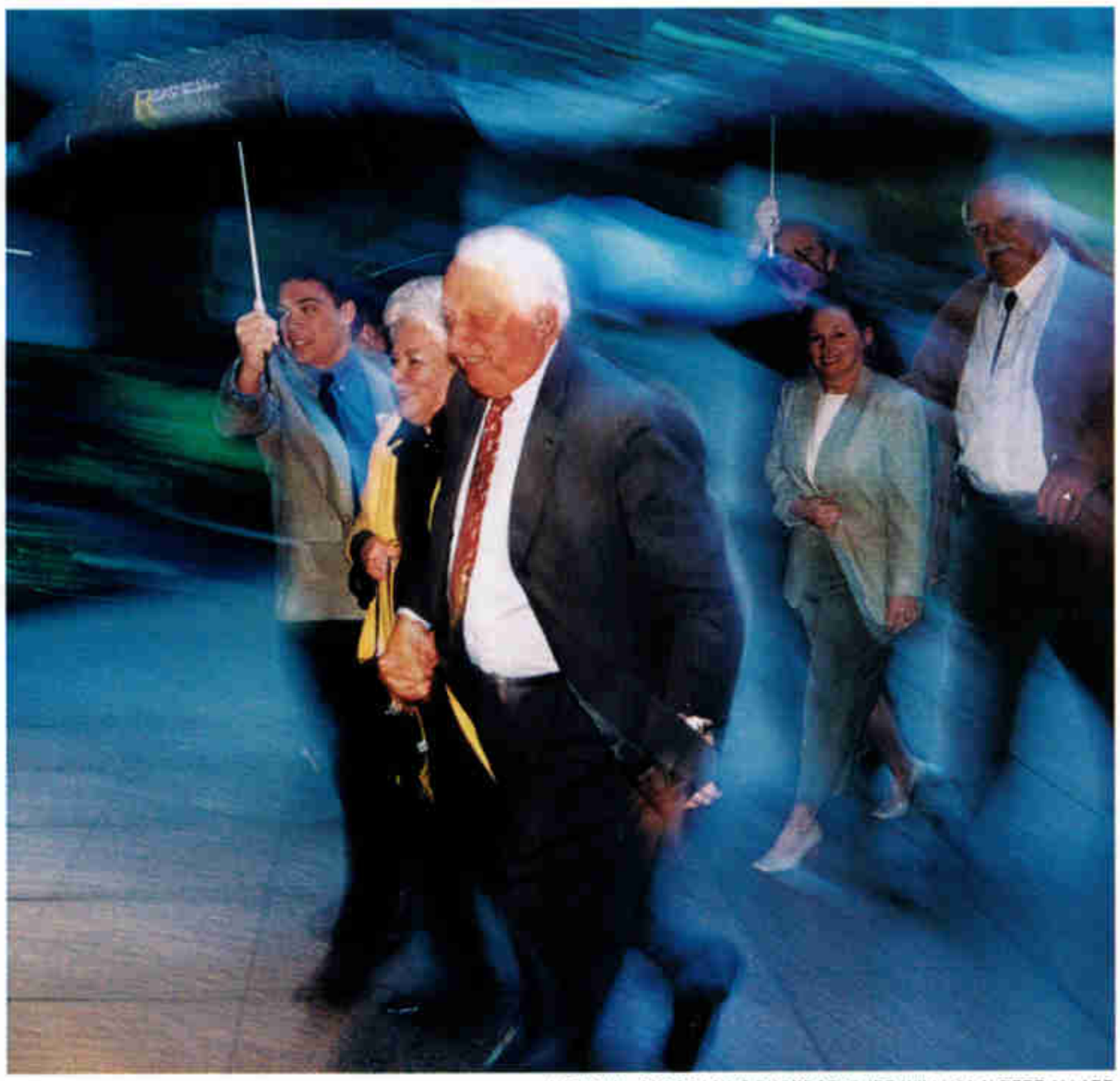
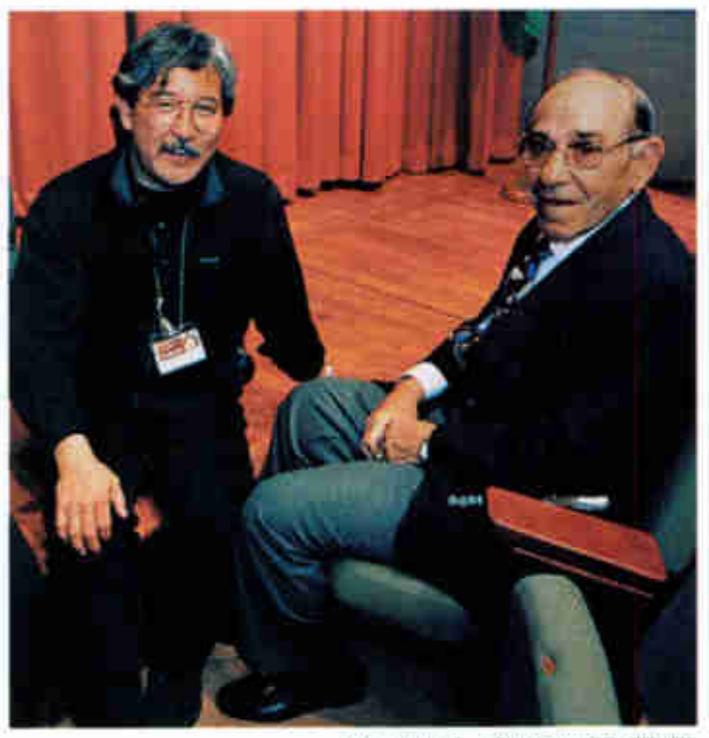
Behind the SCENES

AT THE NATIONAL GEOGRAPHIC SOCIETY



NATIONAL GEOGRAPHIC PHOTOGRAPHER WILLIAM ALBERT ALLARD



BOTH BY O. LOUIS MAZZATENTA

NGS Turns a Double Play

We team with Hall of Fame for baseball anthology

Geographic staffers who love baseball were in paradise recently when childhood idols strolled into our courtyard. Stan Musial. Reggie Jackson. Ernie Banks. Tommy Lasorda (above), who managed the Los Angeles Dodgers for 20 years. More than 40 members of the National Baseball Hall of Fame came to a reception announcing *Baseball as America*, a 320-page retrospective to be published by National Geographic Books next March. With 200 illustrations and essays by observers of the game like writers John Grisham and Roger Kahn, the book will accompany the first ever traveling exhibit of Hall of Fame treasures.

Photographer Mike Yamashita (bottom right) grew up in Montclair, New Jersey, as a neighbor of legendary Yankee catcher Yogi Berra, at right. And photographer Sam Abell (top right, at left), an Ohioan, idolized Cleveland Indians pitcher Bob Feller. During World War II Feller sailed aboard the battleship U.S.S. *Alabama*. "Seaplanes flew NATIONAL GEOGRAPHIC magazines in to us every month," he recalls. "The maps were better than what the Pentagon gave us."

Hall of Fame president Dale Petroskey worked for 11 years for the Society, where he knew the late editor Joe Judge, whose father played 18 years for the Washington Senators. Ten years ago Joe asked Dale to see if his father, who had amassed impressive statistics, deserved a place in the Hall. Although Joe Sr.'s numbers fell short, Dale aided his election to the Hall of Stars at RFK Stadium, which honors Washington, D.C., sports figures.

100 YEARS AGO

October

"William McKinley, President of the United States, most honored and best beloved of Americans, an honorary member of the National Geographic Society, died from an assassin's bullet September 14, 1901, in the fifty-ninth year of his age. R.I.P." —*Frontispiece*

Allergy Season?

Allegra Season!

Seasonal allergies can make you feel miserable. Only once-daily Allegra 180 mg tablets have fexofenadine for long lasting, non-drowsy allergy relief, so you can feel more like yourself again. For people 12 and older. Side effects with Allegra 180mg are low and may include headache, upper respiratory tract infection and back pain. Please see additional important information on the next page. 1-800-ALLEGRA www.allegra.com Call your doctor or pharmacist now for more information.

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Brief Summary of Prescribing Information as of November 2000

ALLEGRA®
(fexofenadine hydrochloride)
Capsules and Tablets

INDICATIONS AND USAGE
Seasonal Allergic Rhinitis

ALLEGRA is indicated for the relief of symptoms associated with seasonal allergic rhinitis in adults and children 6 years of age and older. Symptoms treated effectively were sneezing, rhinorrhea, itchy nose/palate/throat, itchy/watery/red eyes.

Chronic Idiopathic Urticaria

ALLEGRA is indicated for treatment of uncomplicated skin manifestations of chronic idiopathic urticaria in adults and children 6 years of age and older. It significantly reduces pruritus and the number of wheals.

CONTRAINDICATIONS
ALLEGRA is contraindicated in patients with known hypersensitivity to any of its ingredients.

PRECAUTIONS
Drug Interaction with Erythromycin and Ketoconazole

Fexofenadine hydrochloride has been shown to exhibit minimal (ca. 5%) metabolism. However, co-administration of fexofenadine hydrochloride with ketoconazole and erythromycin led to increased plasma levels of fexofenadine hydrochloride. Fexofenadine hydrochloride had no effect on the pharmacokinetics of erythromycin and ketoconazole. In two separate studies, fexofenadine hydrochloride 120 mg twice daily (two times the recommended twice daily dose) was co-administered with erythromycin 500 mg every 8 hours or ketoconazole 400 mg once daily under steady-state conditions to normal, healthy volunteers (n=24, each study). No differences in adverse events or QT_c interval were observed when patients were administered fexofenadine hydrochloride alone or in combination with erythromycin or ketoconazole. The findings of these studies are summarized in the following table:

Effects on steady-state fexofenadine hydrochloride pharmacokinetics after 7 days of co-administration with fexofenadine hydrochloride 120 mg every 12 hours (two times the recommended twice daily dose) in normal volunteers (n=24)

Concomitant Drug	*C_{maxSS} (Peak plasma concentration)*	*$AUC_{ss(0\text{-}12h)}$ (Extent of systemic exposure)*
Erythromycin (500 mg every 8 hrs)	+82%	+109%
Ketoconazole (400 mg once daily)	+135%	+164%

The changes in plasma levels were within the range of plasma levels achieved in adequate and well-controlled clinical trials.

The mechanism of these interactions has been evaluated in *in vitro*, *in situ*, and *in vivo* animal models. These studies indicate that ketoconazole or erythromycin co-administration enhances fexofenadine gastrointestinal absorption. *In vivo* animal studies also suggest that in addition to increasing absorption, ketoconazole decreases fexofenadine hydrochloride gastrointestinal secretion, while erythromycin may also decrease biliary excretion.

Drug Interactions with Antacids

Administration of 120 mg of fexofenadine hydrochloride (2 x 60 mg capsule) within 15 minutes of an aluminum and magnesium containing antacid (Maalox®) decreased fexofenadine AUC by 41% and C_{max} by 43%. ALLEGRA should not be taken closely in time with aluminum and magnesium containing antacids.

Carcinogenesis, Mutagenesis, Impairment of Fertility

The carcinogenic potential and reproductive toxicity of fexofenadine hydrochloride were assessed using terfenadine studies with adequate fexofenadine hydrochloride exposure (based on plasma area-under-the-concentration vs. time [AUC] values). No evidence of carcinogenicity was observed in an 18-month study in mice and in a 24-month study in rats at oral doses up to 150 mg/kg of terfenadine (which led to fexofenadine exposures that were respectively approximately 3 and 5 times the exposure from the maximum recommended daily oral dose of fexofenadine hydrochloride in adults and children).

In *in vitro* (Bacterial Reverse Mutation, CHO/HGPRT Forward Mutation, and Rat Lymphocyte Chromosomal Aberration assays) and *in vivo* (Mouse Bone Marrow Micronucleus assay) tests, fexofenadine hydrochloride revealed no evidence of mutagenicity.

In rat fertility studies, dose-related reductions in implants and increases in postimplantation losses were observed at an oral dose of 150 mg/kg of terfenadine (which led to fexofenadine hydrochloride exposures that were approximately 3 times the exposure of the maximum recommended daily oral dose of fexofenadine hydrochloride in adults).

Pregnancy

Teratogenic Effects: Category C. There was no evidence of teratogenicity in rats or rabbits at oral doses of terfenadine up to 300 mg/kg (which led to fexofenadine exposures that were approximately 4 and 31 times, respectively, the exposure from the maximum recommended daily oral dose of fexofenadine in adults).

There are no adequate and well controlled studies in pregnant women. Fexofenadine should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus.

Nonteratogenic Effects. Dose-related decreases in pup weight gain and survival were observed in rats exposed to an oral dose of 150 mg/kg of terfenadine (approximately 3 times the maximum recommended daily oral dose of fexofenadine hydrochloride in adults based on comparison of fexofenadine hydrochloride AUCs).

Nursing Mothers

There are no adequate and well-controlled studies in women during lactation. Because many drugs are excreted in human milk, caution should be exercised when fexofenadine hydrochloride is administered to a nursing woman.

Pediatric Use

The recommended dose in patients 6 to 11 years of age is based on cross-study comparison of the pharmacokinetics of ALLEGRA in adults and pediatric patients and on the safety profile of fexofenadine hydrochloride in both adult and pediatric patients at doses equal to or higher than the recommended doses.

The safety of ALLEGRA tablets at a dose of 30 mg twice daily has been demonstrated in 438 pediatric patients 6 to 11 years of age in two placebo-controlled 2-week seasonal allergic rhinitis trials. The safety of ALLEGRA for the treatment of chronic idiopathic urticaria in patients 6 to 11 years of age is based on cross-study comparison of the pharmacokinetics of ALLEGRA in adult and pediatric patients and on the safety profile of fexofenadine in both adult and pediatric patients at doses equal to or higher than the recommended dose.

The effectiveness of ALLEGRA for the treatment of seasonal allergic rhinitis in patients 6 to 11 years of age was demonstrated in one trial (n=411) in which ALLEGRA tablets 30 mg twice daily significantly reduced total symptom scores compared to placebo, along with extrapolation of demonstrated efficacy in patients ages 12 years and above, and the pharmacokinetic comparisons in adults and children. The effectiveness of ALLEGRA for the treatment of chronic idiopathic urticaria in patients 6 to 11 years of age is based on an extrapolation of the demonstrated efficacy of ALLEGRA in adults with this condition and the likelihood that the disease course, pathophysiology and the drug's effect are substantially similar in children to that of adult patients.

The safety and effectiveness of ALLEGRA in pediatric patients under 6 years of age have not been established.

Geriatric Use

Clinical studies of ALLEGRA tablets and capsules did not include sufficient numbers of subjects aged 65 years and over to determine whether this population responds differently from younger patients. Other reported clinical experience has not identified differences in responses between the geriatric and younger patients. This drug is known to be substantially excreted by the kidney, and the risk of toxic reactions to this drug may be greater in patients with impaired renal function. Because elderly patients are more likely to have decreased renal function, care should be taken in dose selection, and may be useful to monitor renal function. (See CLINICAL PHARMACOLOGY).

ADVERSE REACTIONS
Seasonal Allergic Rhinitis

Adults. In placebo-controlled seasonal allergic rhinitis clinical trials in patients 12 years of age and older, *which included 2461 patients* receiving fexofenadine hydrochloride capsules at doses of 20 mg to 240 mg twice daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. All adverse events that were reported by greater than 1% of patients who received the recommended daily dose of fexofenadine hydrochloride (60 mg capsules twice daily), and that were more common with fexofenadine hydrochloride than placebo, are listed in Table 1.

In a placebo-controlled clinical study in the United States, which included 570 patients aged 12 years and older receiving fexofenadine hydrochloride tablets at doses of 120 or 180 mg once daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. Table 1 also lists adverse experiences that were reported by greater than 2% of patients treated with fexofenadine hydrochloride tablets at doses of 180 mg once daily and that were more common with fexofenadine hydrochloride than placebo.

The incidence of adverse events, including drowsiness, was not dose-related and was similar across subgroups defined by age, gender, and race.

Table 1

Adverse experiences in patients ages 12 years and older reported in placebo-controlled seasonal allergic rhinitis clinical trials in the United States

Twice daily dosing with fexofenadine capsules at rates of greater than 1%

Adverse experience	*Fexofenadine 60 mg Twice Daily (n=679)*	*Placebo Twice Daily (n=671)*
Viral Infection (cold, flu)	2.5%	1.5%
Nausea	1.6%	1.5%
Dysmenorrhea	1.5%	0.3%
Drowsiness	1.3%	0.9%
Dyspepsia	1.3%	0.6%
Fatigue	1.3%	0.9%

Once daily dosing with fexofenadine hydrochloride tablets at rates of greater than 2%

Adverse experience	*Fexofenadine 180 mg once daily (n=283)*	*Placebo (n=293)*
Headache	10.6%	7.5%
Upper Respiratory Tract Infection	3.2%	3.1%
Back Pain	2.8%	1.4%

The frequency and magnitude of laboratory abnormalities were similar in fexofenadine hydrochloride and placebo-treated patients.

Pediatric. Table 2 lists adverse experiences in patients aged 6 to 11 years of age which were reported by greater than 2% of patients treated with fexofenadine hydrochloride tablets at a dose of 30 mg twice daily in placebo-controlled seasonal allergic rhinitis studies in the United States and Canada that were more common with fexofenadine hydrochloride than placebo.

Table 2

Adverse experiences reported in placebo-controlled seasonal allergic rhinitis studies in pediatric patients ages 6 to 11 in the United States and Canada at rates of greater than 2%

Adverse experience	*Fexofenadine 30 mg twice daily (n=209)*	*Placebo (n=229)*
Headache	7.2%	6.6%
Accidental Injury	2.9%	1.3%
Coughing	3.8%	1.3%
Fever	2.4%	0.9%
Pain	2.4%	0.4%
Otitis Media	2.4%	0.0%
Upper Respiratory Tract Infection	4.3%	1.7%

Chronic Idiopathic Urticaria

Adverse events reported by patients 12 years of age and older in placebo-controlled chronic idiopathic urticaria studies were similar to those reported in placebo-controlled seasonal allergic rhinitis studies. In placebo-controlled chronic idiopathic urticaria clinical trials, which included 726 patients 12 years of age and older receiving fexofenadine hydrochloride tablets at doses of 20 to 240 mg twice daily, adverse events were similar in fexofenadine hydrochloride and placebo-treated patients. Table 3 lists adverse experiences in patients aged 12 years and older which were reported by greater than 2% of patients treated with fexofenadine hydrochloride 60 mg tablets twice daily in controlled clinical studies in the United States and Canada and that were more common with fexofenadine hydrochloride than placebo. The safety of fexofenadine hydrochloride in the treatment of chronic idiopathic urticaria in pediatric patients 6 to 11 years of age is based on the safety profile of fexofenadine hydrochloride in adults and adolescent patients at doses equal to or higher than the recommended dose (see Pediatric Use).

Table 3

Adverse experiences reported in patients 12 years and older in placebo-controlled chronic idiopathic urticaria studies in the United States and Canada at rates of greater than 2%

Adverse experience	*Fexofenadine 60 mg twice daily (n=186)*	*Placebo (n=178)*
Back Pain	2.2%	1.1%
Sinusitis	2.2%	1.1%
Dizziness	2.2%	0.6%
Drowsiness	2.2%	0.0%

Events that have been reported during controlled clinical trials involving seasonal allergic rhinitis and chronic idiopathic urticaria patients with incidences less than 1% and similar to placebo and have been rarely reported during postmarketing surveillance include: insomnia, nervousness, and sleep disorders or paroniria. In rare cases, rash, urticaria, pruritus and hypersensitivity reactions with manifestations such as angioedema, chest tightness, dyspnea, flushing and systemic anaphylaxis have been reported.

OVERDOSAGE
Reports of fexofenadine hydrochloride overdose have been infrequent and contain limited information. However, dizziness, drowsiness, and dry mouth have been reported. Single doses of fexofenadine hydrochloride up to 800 mg (six normal volunteers at this dose level), and doses up to 690 mg twice daily for 1 month (three normal volunteers at this dose level) or 240 mg once daily for 1 year (234 normal volunteers at this dose level) were administered without the development of clinically significant adverse events as compared to placebo.

In the event of overdose, consider standard measures to remove any unabsorbed drug. Symptomatic and supportive treatment is recommended.

Hemodialysis did not effectively remove fexofenadine hydrochloride from blood (1.7% removed) following terfenadine administration.

No deaths occurred at oral doses of fexofenadine hydrochloride up to 5000 mg/kg in mice (110 times the maximum recommended daily oral dose in adults and 200 times the maximum recommended daily oral dose in children based on mg/m^2) and up to 5000 mg/kg in rats (230 times the maximum recommended daily oral dose in adults and 400 times the maximum recommended daily oral dose in children based on mg/m^2). Additionally, no clinical signs of toxicity or gross pathological findings were observed. In dogs, no evidence of toxicity was observed at oral doses up to 2000 mg/kg (300 times the maximum recommended daily oral dose in adults and 530 times the maximum recommended daily oral dose in children based on mg/m^2).

Prescribing Information as of November 2000

Aventis Pharmaceuticals Inc.
Kansas City, MO 64137 USA

US Patents 4,254,129; 5,375,693; 5,578,610

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Putting Their Music on the Map

Diverse traditions drive Society staffers to perform

Belting out the blues at a Washington nightclub, Mary Shaver (above) displays the passion that led a *Washington Post* reviewer to praise her "vocal power and grit." A paralegal in our law, business, and governmental affairs division, Mary is one of several staff members with second lives as professional musicians. True to an organization that covers the world's cultures, their interests range the globe, featuring a variety of musical styles from the U.S. and abroad.

A Maryland native, Mary was taken by soul music as a child listening to the radio. The "blues bug bit" when she joined a professional band as its lead singer in 1989. "The blues holds raw, emotional feelings I've never really felt in other forms of music," she says. In 1999 she cut a CD, and she now appears with her own band and others three or four times a month.

For Angela Botzer (right) an interest in old-time Appalachian dance music led to a study of its roots in the British Isles. Her band, the Hedgerows, plays Irish traditional music regularly at an Annapolis, Maryland, pub and at dances and concerts. "We want to show there's a whole world of Irish music outside of St. Patrick's Day," says Angela, production coordinator for our international editions.

Tom Gray (bottom right) discovered bluegrass music when he was 14 and is now one of its most honored players. He joined his first professional band as a bassist in 1960, the same year he joined our cartographic division, and has been in two major bluegrass groups, the Country Gentlemen and the Seldom Scene. He plays traditional jazz as well.

ALL BY JONATHAN KIRSHNER

"There's a link between music and geography," says Tom, now a contract map editor in our book division. "So many of the songs I play are about places. When you play the tunes, you get images of those places in your head."

Photographed by Jose and Adriana Calo

WILDLIFE AS CANON SEES IT

Black-fronted piping-guans forage along a river in Argentina's Uruguaí Provincial Park. Alone, in pairs or small groups, these large, forest-dwelling birds often stay for several days around a fruiting tree. As it eats mainly fruit, the piping-guan plays an important role in the regeneration of forests through seed dispersal. If disturbed, the bird remains motionless high in the trees rather than flying away. Once abundant, the black-fronted piping-guan has disappeared from much of its former range; intense hunting pressure and habitat destruction have caused a severe and rapid decline in numbers. Effective protection is vital to its survival.

As a global corporation committed to social and environmental concerns, we join in worldwide efforts to promote greater awareness of endangered species for the benefit of future generations.

Black-fronted Piping-guan *(Pipile jacutinga)*
Size: Length, 63-74 cm
Weight: Average 1.5 kg
Habitat: Atlantic forest region of south-eastern Brazil, eastern Paraguay and north-eastern Argentina
Surviving number: Estimated at fewer than 10,000

The Nature Conservancy®
Saving the Last Great Places

Canon makes possible The Nature Conservancy's "Wings of the Americas" program which protects birds and their habitats throughout the Americas.

Canon

CARSTEN PETER (ABOVE); HEINZ ZAK

Magazines Hit the Mark

GEOGRAPHIC *and* ADVENTURE *earn national awards*

Carsten Peter's image of a South Pacific volcano in the November 2000 issue (above) was exceptional, and typical. "You expect to find great photography in NATIONAL GEOGRAPHIC," said the citation honoring us with the National Magazine Award for photography. "Yet somehow, the insights and immediacy of this magazine's visuals still end up surprising you." Our contributors have taken us to the summit before: We have won three National Magazine Awards—or Ellies, after Alexander Calder's "Elephant" sculpture—for general excellence, five for photography.

In just its second year, *National Geographic Adventure* won its first Ellie, for personal service. Judges called its Jan./Feb. 2000 article "The Rules of Adventure" (below) "a service piece that might actually save lives . . . an indispensable guide for adventure travelers, designed to ensure that all trips are return trips."

MARK THIESSEN, NGS

A Gift Made With Loving Hands

We've always known that we have devoted readers. But Mieczyslaw Staniszewski showed just how devoted some are when he sent us—unsolicited and unexpectedly—this rendition of a cover in a beautifully crafted frame with more than ten kinds of wood. Mieczyslaw, a mechanic in Swarzedz, Poland, is a woodworking hobbyist who has long been a fan of the magazine. When photographer Tomasz Tomaszewski called to thank him for the gift, which now hangs in Editor Bill Allen's office, Mieczyslaw was, appropriately, reading the latest issue.

FOR MORE INFORMATION

Call: 1-800-NGS-LINE
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ExxonMobil	up to 2 cents per gallon
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Century 21®, Coldwell Banker® and ERA® offices	.5% of sale price**
America Online	$50 for new or referred account
Staples	2% of purchases
Borders® and Waldenbooks®	2% of purchases
7,400 Restaurants	10% of total bill
70+ Online Shopping Sites	up to 15% of purchases

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Wouldn't it be nice if you could grow your child's college fund by buying the car of your dreams? We think so. That's why General Motors is the sole automotive sponsor of Upromise, a whole new way to save for college. Here's how it works: Join Upromise, buy or lease a new GM vehicle and we will contribute $150 to your Upromise college savings account. If anyone else in your family, or even a friend, joins Upromise and buys or leases a vehicle, that purchase can count too. Plus, hundreds of other companies, including AT&T, ExxonMobil, McDonald's® and Toys "R" Us will also contribute a portion of your spending with them to your Upromise college savings account. It could easily add up to thousands of dollars for college. If there's a college-bound child in your family, there should be a GM car in your garage.

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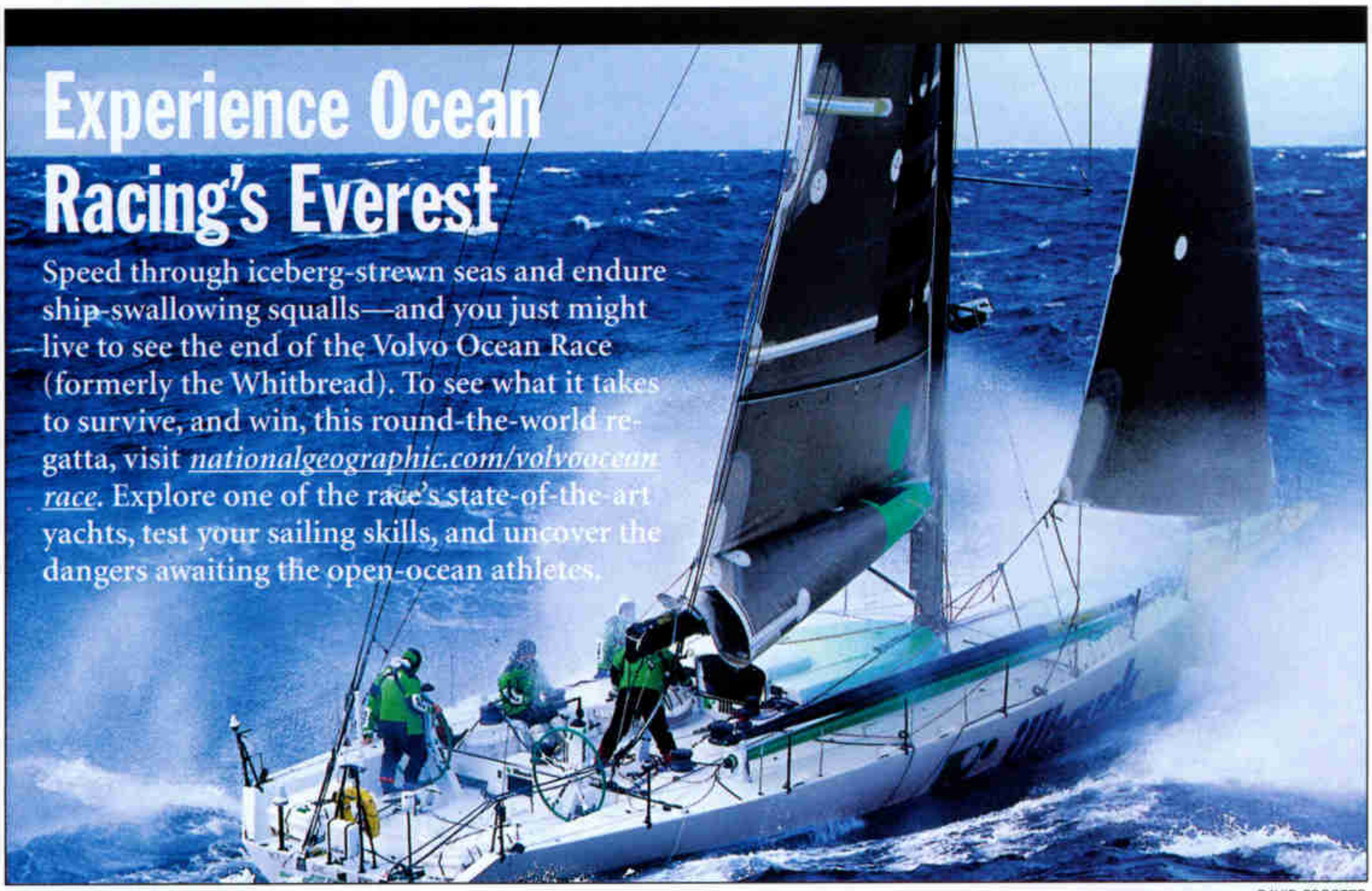

Experience Ocean Racing's Everest

Speed through iceberg-strewn seas and endure ship-swallowing squalls—and you just might live to see the end of the Volvo Ocean Race (formerly the Whitbread). To see what it takes to survive, and win, this round-the-world regatta, visit *nationalgeographic.com/volvooceanrace*. Explore one of the race's state-of-the-art yachts, test your sailing skills, and uncover the dangers awaiting the open-ocean athletes.

DAVID FORSTER

Useful Tools

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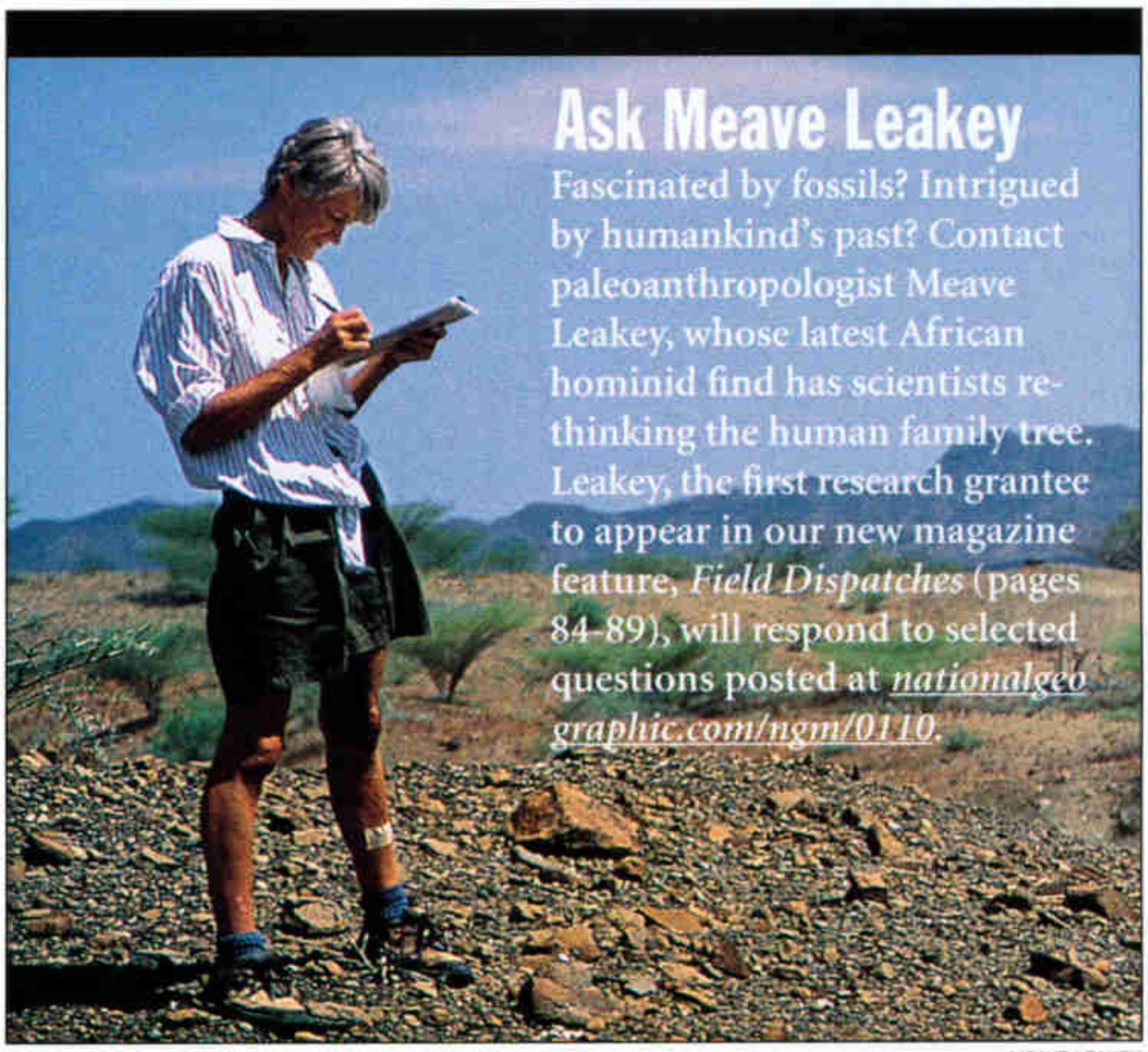

Ask Meave Leakey

Fascinated by fossils? Intrigued by humankind's past? Contact paleoanthropologist Meave Leakey, whose latest African hominid find has scientists rethinking the human family tree. Leakey, the first research grantee to appear in our new magazine feature, *Field Dispatches* (pages 84-89), will respond to selected questions posted at *nationalgeographic.com/ngm/0110*.

MEAVE LEAKEY

E-mail online@nationalgeographic.com **National Geographic Store** nationalgeographic.com/store **E-mail newsletter** Register at nationalgeographic.com/register.html **Member Services E-mail** ngsline@customersvc.com

If you're in Mr. Garwick's class, you're going to pay.

The good news is that Mr. Garwick pays students to attend class. The bad news is that everything – chairs, desks, even trips to the water fountain – must be purchased.

It's his ingenious way of making math fun for sixth graders while teaching them the concepts of saving, spending, banking and supply & demand.

For selling kids on the importance of math, State Farm is pleased to present Ken Garwick with our Good Neighbor Teacher Award™ and to donate $10,000 to Marlatt Elementary School in Manhattan, Kansas.

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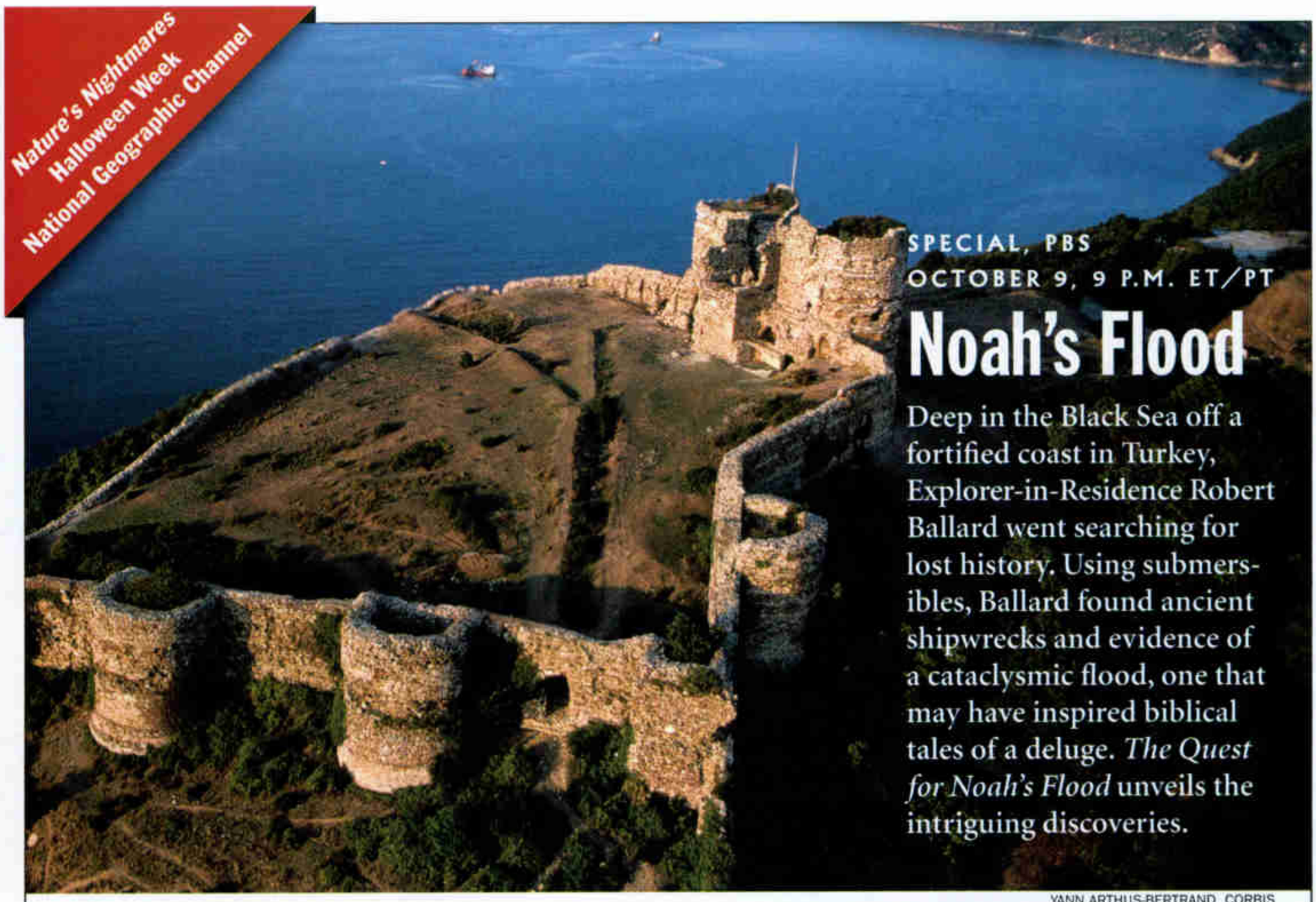


SPECIAL, PBS
OCTOBER 9, 9 P.M. ET/PT

Noah's Flood

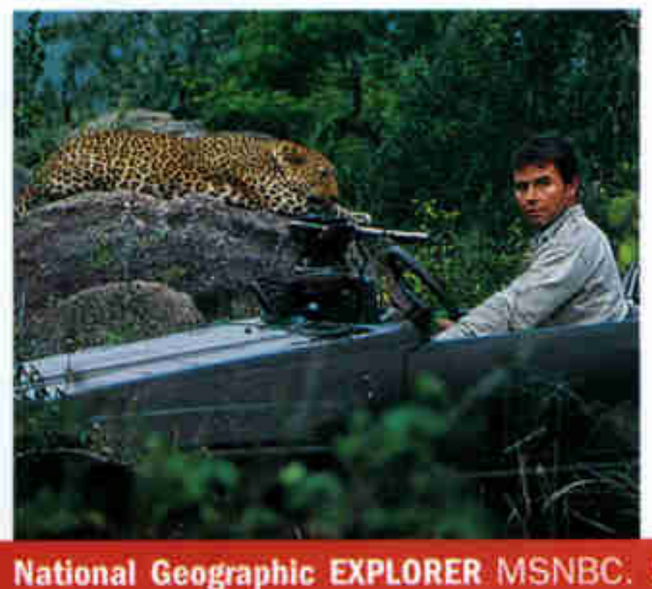
Deep in the Black Sea off a fortified coast in Turkey, Explorer-in-Residence Robert Ballard went searching for lost history. Using submersibles, Ballard found ancient shipwrecks and evidence of a cataclysmic flood, one that may have inspired biblical tales of a deluge. *The Quest for Noah's Flood* unveils the intriguing discoveries.

YANN ARTHUS-BERTRAND, CORBIS

EXPLORER, MSNBC
OCTOBER 7, 8 P.M. ET/PT

Leopards

Tjololo, a male leopard, accepts the company of filmmaker Kim Wolhuter. Two years of contact in the South African wilds provide amazing action scenes in *Stalking Leopards.*



REZA (ABOVE); DALE HANCOCK

NATIONAL GEOGRAPHIC CHANNEL

Witness to War

Villagers ferry photographer Reza, in white *pakol,* and *Perfect Storm* author Sebastian Junger, seated, across a river to report on Afghanistan's civil war. *Into the Forbidden Zone,* from the new series *Frontline Diaries,* reveals the human face of war.

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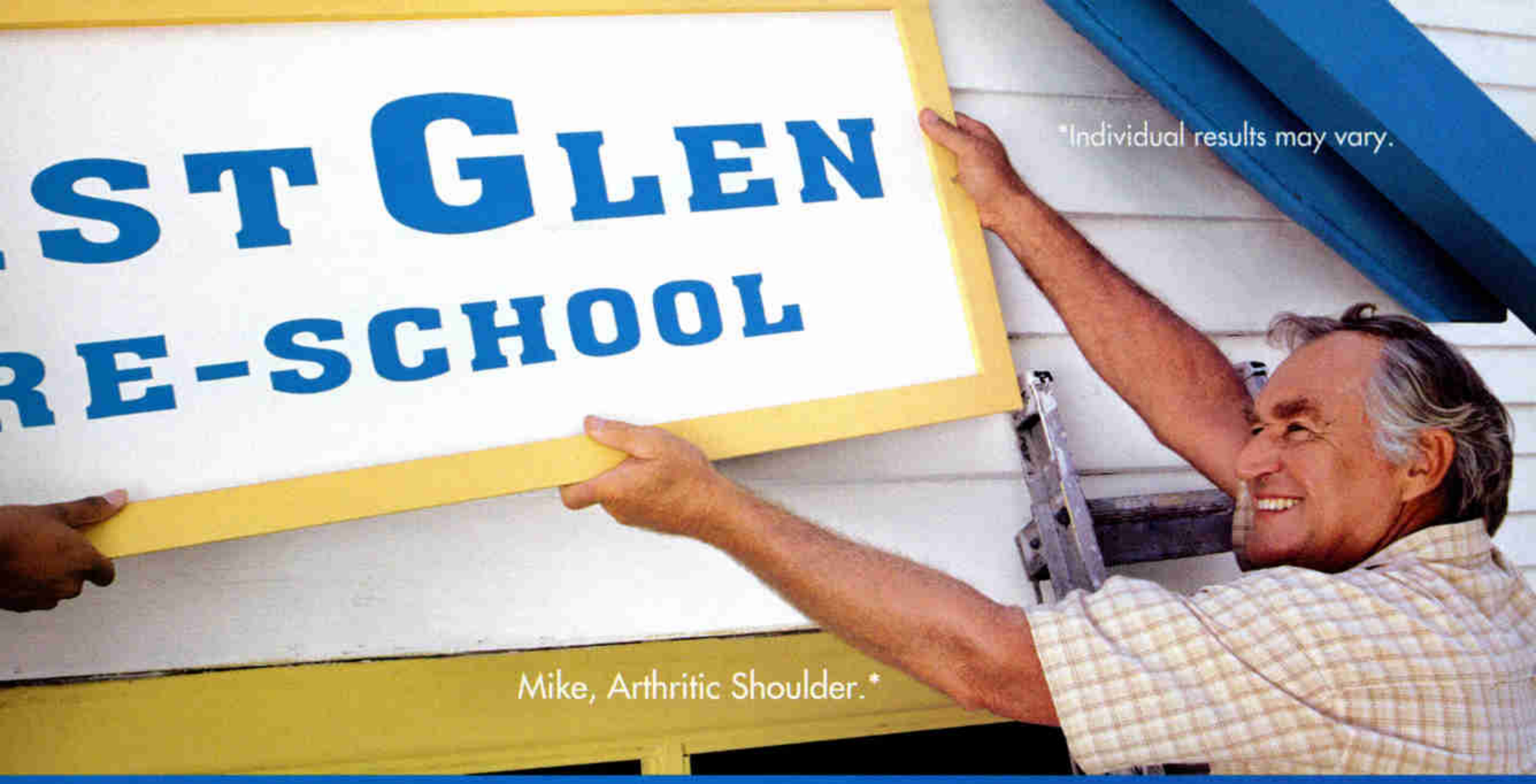

*Individual results may vary.

Mike, Arthritic Shoulder.*

Celebrate

Powerful 24-hour Relief from Osteoarthritis

PAIN ▪ INFLAMMATION ▪ STIFFNESS

Celebrex is the first prescription arthritis medicine that specifically targets only the COX-2 enzyme – a key source of arthritis pain. Celebrex can help you through the day with activities like walking, standing or climbing stairs, and through the night while resting in bed. And that's definitely worth celebrating.

Important Celebrex Information. Celebrex should not be taken in late pregnancy or if you've had aspirin-sensitive asthma or allergic reactions to aspirin or other arthritis medicines or certain drugs called sulfonamides. In rare cases serious stomach problems, such as bleeding can occur without warning. The most common side effects in clinical trials were indigestion, diarrhea and abdominal pain. Tell your doctor if you have kidney or liver problems. For more information, call 1-888-Celebrex or visit www.celebrex.com.

Ask Your Doctor If A Free Sample Of Celebrex Is Right For You.

CELEBREX®
(CELECOXIB CAPSULES) 100 mg 200 mg

Please see important product information on adjacent page.

 UX0012323

PHARMACIA Pfizer

BRIEF SUMMARY—CELEBREX® (celecoxib capsules)

Before prescribing, please consult complete prescribing information.

INDICATIONS AND USAGE

For relief of the signs and symptoms of OA, and of RA in adults.

CONTRAINDICATIONS

CELEBREX is contraindicated in patients with known hypersensitivity to celecoxib. CELEBREX should not be given to patients who have demonstrated allergic-type reactions to sulfonamides. CELEBREX should not be given to patients who have experienced asthma, urticaria, or allergic-type reactions after taking aspirin or other NSAIDs. Severe, rarely fatal, anaphylactic-like reactions to NSAIDs have been reported in such patients (see WARNINGS — Anaphylactoid Reactions, and PRECAUTIONS — Preexisting Asthma).

WARNINGS

Gastrointestinal (GI) Effects — Risk of GI Ulceration, Bleeding, and Perforation: Serious GI toxicity such as bleeding, ulceration, and perforation of the stomach, small intestine or large intestine, can occur at any time, with or without warning symptoms, in patients treated with NSAIDs. Minor upper GI problems, such as dyspepsia, are common and may also occur at any time during NSAID therapy. Therefore, physicians and patients should remain alert for ulceration and bleeding, even in the absence of previous GI tract symptoms. Patients should be informed about the signs and/or symptoms of serious GI toxicity and the steps to take if they occur. Only 1/5 patients who develop a serious upper GI adverse event on NSAID therapy is symptomatic. Upper GI ulcers, gross bleeding or perforation, caused by NSAIDs, appear to occur in approximately 1% of patients treated for 3–6 months, and in about 2–4% of patients treated for one year. These trends continue thus, increasing the likelihood of developing a serious GI event at some time during the course of therapy. However, even short-term therapy is not without risk. It is unclear, at the present time, how the above rates apply to CELEBREX (see CLINICAL STUDIES — Special Studies in the complete prescribing information). Among 5,285 patients who received CELEBREX in controlled clinical trials of 1 to 6 months duration (most were 3 month studies) at a daily dose of 200 mg or more, 2 (0.04%) experienced significant upper GI bleeding, at 14 and 22 days after initiation of dosing. Approximately 40% of these 5,285 patients were in studies that required them to be free of ulcers by endoscopy at study entry. Thus it is unclear if this study population is representative of the general population. Prospective, long-term studies required to compare the incidence of serious, clinically significant upper GI adverse events in patients taking CELEBREX vs. comparator NSAID products have not been performed. NSAIDs should be prescribed with extreme caution in patients with a prior history of ulcer disease or GI bleeding. Most spontaneous reports of fatal GI events are in elderly or debilitated patients and therefore special care should be taken in treating this population. **To minimize the potential risk for an adverse GI event, the lowest effective dose should be used for the shortest possible duration.** For high risk patients, alternate therapies that do not involve NSAIDs should be considered. Studies have shown that patients with a *prior history of peptic ulcer disease and/or GI bleeding* and who use NSAIDs, have a greater than 10-fold higher risk for developing a GI bleed than patients with neither of these risk factors. In addition to a past history of ulcer disease, pharmacoepidemiological studies have identified several other co-therapies or co-morbid conditions that may increase the risk for GI bleeding such as: treatment with oral corticosteroids, treatment with anticoagulants, longer duration of NSAID therapy, smoking, alcoholism, older age, and poor general health status.

Anaphylactoid Reactions: As with NSAIDs in general, anaphylactoid reactions have occurred in patients without known prior exposure to CELEBREX. In post-marketing experience, rare cases of anaphylactic reactions and angioedema have been reported in patients receiving CELEBREX. CELEBREX should not be given to patients with the aspirin triad. This symptom complex typically occurs in asthmatic patients who experience rhinitis with or without nasal polyps, or who exhibit severe, potentially fatal bronchospasm after taking aspirin or other NSAIDs (see CONTRAINDICATIONS and PRECAUTIONS — Preexisting Asthma). Emergency help should be sought in cases where an anaphylactoid reaction occurs.

Advanced Renal Disease: Treatment with CELEBREX is not recommended.

Pregnancy: In late pregnancy CELEBREX should be avoided because it may cause premature closure of the ductus arteriosus.

PRECAUTIONS

General: CELEBREX cannot be expected to substitute for corticosteroids or to treat corticosteroid insufficiency. The pharmacological activity of CELEBREX in reducing inflammation, and possibly fever, may diminish the utility of these diagnostic signs in detecting infectious complications of presumed noninfectious, painful conditions.

Hepatic Effects: Borderline elevations of one or more liver tests may occur in up to 15% of patients taking NSAIDs, and notable elevations of ALT or AST (approximately three or more times the upper limit of normal) have been reported in approximately 1% of patients in clinical trials with NSAIDs. These laboratory abnormalities may progress, may remain unchanged, or may be transient with continuing therapy. Rare cases of severe hepatic reactions, including jaundice and fatal fulminant hepatitis, liver necrosis and hepatic failure (some with fatal outcome) have been reported with NSAIDs, including CELEBREX. (See ADVERSE REACTIONS — post-marketing experience.) In controlled clinical trials of CELEBREX, the incidence of borderline elevations of liver tests was 6% for CELEBREX and 5% for placebo, and approximately 0.2% of patients taking CELEBREX and 0.3% of patients taking placebo had notable elevations of ALT and AST. A patient with symptoms and/or signs suggesting liver dysfunction, or in whom an abnormal liver test has occurred, should be monitored carefully for evidence of the development of a more severe hepatic reaction while on therapy with CELEBREX. If clinical signs and symptoms consistent with liver disease develop, or if systemic manifestations occur (e.g., eosinophilia, rash, etc.), CELEBREX should be discontinued.

Renal Effects: Long-term administration of NSAIDs has resulted in renal papillary necrosis and other renal injury. Renal toxicity has also been seen in patients in whom renal prostaglandins have a compensatory role in the maintenance of renal perfusion. In these patients, administration of an NSAID may cause a dose-dependent reduction in prostaglandin formation and, secondarily, in renal blood flow, which may precipitate overt renal decompensation. Patients at greatest risk of this reaction are those with impaired renal function, heart failure, or liver dysfunction, those taking diuretics and ACE inhibitors, and the elderly. Discontinuation of NSAID therapy is usually followed by recovery to the pretreatment state. Clinical trials with CELEBREX have shown renal effects similar to those observed with comparator NSAIDs. Caution should be used when initiating treatment with CELEBREX in patients with considerable dehydration. It is advisable to rehydrate patients first and then start therapy with CELEBREX. Caution is also recommended in patients with pre-existing kidney disease (see WARNINGS — Advanced Renal Disease).

Hematological Effects: Anemia may occur. In controlled clinical trials the incidence of anemia was 0.6% with CELEBREX and 0.4% with placebo. Patients on long-term treatment with CELEBREX should have their hemoglobin or hematocrit checked if they exhibit any signs or symptoms of anemia or blood loss. CELEBREX does not generally affect platelet counts, prothrombin time (PT), or partial thromboplastin time (PTT), and does not appear to inhibit platelet aggregation at indicated dosages (See CLINICAL STUDIES — Special Studies — Platelets in the complete prescribing information).

Fluid Retention and Edema: Fluid retention and edema may occur (see ADVERSE REACTIONS). Therefore, CELEBREX should be used with caution in patients with fluid retention, hypertension, or heart failure.

Preexisting Asthma: Do not use in patients with aspirin-sensitive asthma because of the risk of severe bronchospasm. Use with caution in patients with preexisting asthma.

Laboratory Tests: Because serious GI tract ulcerations and bleeding can occur without warning symptoms, physicians should monitor for signs or symptoms of GI bleeding. During the controlled clinical trials, there was an increased incidence of hyperchloremia in patients receiving celecoxib compared with patients on placebo. Other laboratory abnormalities that occurred more frequently in the patients receiving celecoxib included hypophosphatemia, and elevated BUN. These laboratory abnormalities were also seen in patients who received comparator NSAIDs in these studies. The clinical significance of these abnormalities has not been established.

Drug Interactions: ***General:*** Celecoxib metabolism is predominantly mediated via cytochrome P450 2C9 in the liver. Co-administration of celecoxib with drugs that are known to inhibit 2C9 should be done with caution. *In vitro* studies indicate that celecoxib, although not a substrate, is an inhibitor of cytochrome P450 2D6. Therefore, there is a potential for an *in vivo* drug interaction with drugs that are metabolized by P450 2D6. ***ACE-inhibitors:*** Reports suggest that NSAIDs may diminish the antihypertensive effect of Angiotensin Converting Enzyme (ACE) inhibitors. This interaction should be given consideration in patients taking CELEBREX concomitantly with ACE-inhibitors. ***Furosemide:*** Clinical studies, as well as post marketing observations, have shown that NSAIDs can reduce the natriuretic effect of furosemide and thiazides in some patients. This response has been attributed to inhibition of renal prostaglandin synthesis. ***Aspirin:*** CELEBREX can be used with low dose aspirin. However, concomitant administration of aspirin with CELEBREX may result in an increased rate of GI ulceration or other complications, compared to use of CELEBREX alone (see CLINICAL STUDIES — Special Studies — Gastrointestinal in the complete prescribing information). Because of its lack of platelet effects, CELEBREX is not a substitute for aspirin for cardiovascular prophylaxis. ***Fluconazole:*** Concomitant administration of fluconazole at 200 mg QD resulted in a two-fold increase in celecoxib plasma concentration. This increase is due to the inhibition of celecoxib metabolism via P450 2C9 by fluconazole (see Pharmacokinetics — Metabolism). CELEBREX should be introduced at the lowest recommended dose in patients receiving fluconazole. ***Lithium:*** In a study conducted in healthy subjects, mean steady-state lithium plasma levels increased approximately 17% in subjects receiving lithium 450 mg BID with CELEBREX 200 mg BID as compared to subjects receiving lithium alone. Patients on lithium treatment should be closely monitored when CELEBREX is introduced or withdrawn. ***Methotrexate:*** In an interaction study of rheumatoid arthritis patients taking methotrexate, CELEBREX did not have a significant effect on the pharmacokinetics of methotrexate. ***Warfarin:*** Anticoagulant activity should be monitored, particularly in the first few days, after initiating or changing CELEBREX therapy in patients receiving warfarin or similar agents, since these patients are at an increased risk of bleeding complications. The effect of celecoxib on the anticoagulant effect of warfarin was studied in a group of healthy subjects receiving daily doses of 2–5 mg of warfarin. In these subjects, celecoxib did not alter the anticoagulant effect of warfarin as determined by prothrombin time. However, in post-marketing experience, bleeding events have been reported, predominantly in the elderly, in association with increases in prothrombin time in patients receiving CELEBREX concurrently with warfarin. **Carcinogenesis, mutagenesis, impairment of fertility:** Celecoxib was not carcinogenic in rats given oral doses up to 200 mg/kg for males and 10 mg/kg for females (approximately 2- to 4-fold the human exposure as measured by the AUC_{0-24} at 200 mg BID) or in mice given oral doses up to 25 mg/kg for males and 50 mg/kg for females (approximately equal to human exposure as measured by the AUC_{0-24} at 200 mg BID) for two years. Celecoxib was not mutagenic in an Ames test and a mutation assay in Chinese hamster ovary (CHO) cells, nor clastogenic in a chromosome aberration assay in CHO cells and an *in vivo* micronucleus test in rat bone marrow. Celecoxib did not impair male and female fertility in rats at oral doses up to 600 mg/kg/day (approximately 11-fold human exposure at 200 mg BID based on the AUC_{0-24}).

Pregnancy: ***Teratogenic effects:*** Pregnancy Category C. Celecoxib was not teratogenic in rabbits up to an oral dose of 60 mg/kg/day (equal to human exposure at 200 mg BID as measured by AUC_{0-24}); however, at oral doses ≥ 150 mg/kg/day (approximately 2-fold human exposure at 200 mg BID as measured by AUC_{0-24}), an increased incidence of fetal alterations, such as ribs fused, sternebrae fused and sternebrae misshapen, was observed. A dose-dependent increase in diaphragmatic hernias was observed in one of two rat studies at oral doses ≥ 30 mg/kg/day (approximately 6-fold human exposure based on the AUC_{0-24} at 200 mg BID). There are no studies in pregnant women. CELEBREX should be used during pregnancy only if the potential benefit justifies the potential risk to the fetus. ***Nonteratogenic effects:*** Celecoxib produced preimplantation and post-implantation losses and reduced embryo/fetal survival in rats at oral dosages ≥ 50 mg/kg/day (approximately 6-fold human exposure based on the AUC_{0-24} at 200 mg BID). These changes are expected with inhibition of prostaglandin synthesis and are not the result of permanent alteration of female reproductive function, nor are they expected at clinical exposures. No studies have been conducted to evaluate the effect of celecoxib on the closure of the ductus arteriosus in humans. Therefore, use of CELEBREX during the third trimester of pregnancy should be avoided. **Labor and delivery:** Celecoxib produced no evidence of delayed labor or parturition at oral doses up to 100 mg/kg in rats (approximately 7-fold human exposure as measured by the AUC_{0-24} at 200 mg BID). The effects of CELEBREX on labor and delivery in pregnant women are unknown. **Nursing mothers:** It is not known whether this drug is excreted in human milk. Because many drugs are excreted in human milk and because of the potential for serious adverse reactions in nursing infants from CELEBREX, a decision should be made whether to discontinue nursing or to discontinue the drug, taking into account the importance of the drug to the mother.

SEARLE Pfizer

CELEBREX® (celecoxib capsules)

Pediatric Use: Safety and effectiveness in pediatric patients below the age of 18 years have not been evaluated.

Geriatric Use: Of the total number of patients who received CELEBREX in clinical trials, more than 2,100 were 65–74 years of age, while approximately 800 additional patients were 75 years and over. While the incidence of adverse experiences tended to be higher in elderly patients, no substantial differences in safety and effectiveness were observed between these subjects and younger subjects. Other reported clinical experience has not identified differences in response between the elderly and younger patients, but greater sensitivity of some older individuals cannot be ruled out. In clinical studies comparing renal function as measured by the GFR, BUN and creatinine, and platelet function as measured by bleeding time and platelet aggregation, the results were not different between elderly and young volunteers.

ADVERSE REACTIONS

Adverse events occurring in ≥ 2% of Celebrex patients from controlled arthritis trials, regardless of causality at recommended doses (N=4146): abdominal pain 4.1%, diarrhea 5.6%, dyspepsia 8.8%, flatulence 2.2%, nausea 3.5%, back pain 2.8%, peripheral edema 2.1%, injury-accidental 2.9%, dizziness 2.0%, headache 15.8%, insomnia 2.3%, pharyngitis 2.3%, rhinitis 2.0%, sinusitis 5.0%, upper respiratory tract infection 8.1%, rash 2.2%. In placebo- or active-controlled clinical trials, the discontinuation rate due to adverse events was 7.1% for patients receiving CELEBREX and 6.1% for patients receiving placebo. Among the most common reasons for discontinuation due to adverse events in the CELEBREX treatment groups were dyspepsia and abdominal pain (cited as reasons for discontinuation in 0.8% and 0.7% of CELEBREX patients, respectively). Among patients receiving placebo, 0.6% discontinued due to dyspepsia and 0.6% withdrew due to abdominal pain. The following adverse events occurred in 0.1–1.9% of patients regardless of causality.

Celebrex (100–200 mg BID or 200 mg QD): ***GI:*** Constipation, diverticulitis, dysphagia, eructation, esophagitis, gastritis, gastroenteritis, gastroesophageal reflux, hemorrhoids, hiatal hernia, melena, dry mouth, stomatitis, tenesmus, tooth disorder, vomiting; ***Cardiovascular:*** Aggravated hypertension, angina pectoris, coronary artery disorder, myocardial infarction; ***General:*** Allergy aggravated, allergic reaction, asthenia, chest pain, cyst NOS, edema generalized, face edema, fatigue, fever, hot flushes, influenza-like symptoms, pain, peripheral pain; ***Resistance mechanism disorders:*** Herpes simplex, herpes zoster, infection bacterial, infection fungal, infection soft tissue, infection viral, moniliasis, moniliasis genital, otitis media; ***Central, peripheral nervous system:*** Leg cramps, hypertonia, hypoesthesia, migraine, neuralgia, neuropathy, paresthesia, vertigo; ***Female reproductive:*** Breast fibroadenosis, breast neoplasm, breast pain, dysmenorrhea, menstrual disorder, vaginal hemorrhage, vaginitis; ***Male reproductive:*** Prostatic disorder; ***Hearing and vestibular:*** Deafness, ear abnormality, earache, tinnitus; ***Heart rate and rhythm:*** Palpitation, tachycardia; ***Liver and biliary system:*** Hepatic function abnormal, SGOT increased, SGPT increased; ***Metabolic and nutritional:*** BUN increased, CPK increased, diabetes mellitus, hypercholesterolemia, hyperglycemia, hypokalemia, NPN increase, creatinine increased, alkaline phosphatase increased, weight increase; ***Musculoskeletal:*** Arthralgia, arthrosis, bone disorder, fracture accidental, myalgia, neck stiffness, synovitis, tendinitis; ***Platelets (bleeding or clotting):*** Ecchymosis, epistaxis, thrombocythemia; ***Psychiatric:*** Anorexia, anxiety, appetite increased, depression, nervousness, somnolence; ***Hemic:*** Anemia; ***Respiratory:*** Bronchitis, bronchospasm, bronchospasm aggravated, coughing, dyspnea, laryngitis, pneumonia; ***Skin and appendages:*** Alopecia, dermatitis, nail disorder, photosensitivity reaction, pruritus, rash erythematous, rash maculopapular, skin disorder, skin dry, sweating increased, urticaria; ***Application site disorders:*** Cellulitis, dermatitis contact, injection site reaction, skin nodule; ***Special senses:*** Taste perversion; ***Urinary system:*** Albuminuria, cystitis, dysuria, hematuria, micturition frequency, renal calculus, urinary incontinence, urinary tract infection; ***Vision:*** Blurred vision, cataract, conjunctivitis, eye pain, glaucoma.

Other serious adverse reactions which occur rarely (estimated < 0.1%), regardless of causality: The following serious adverse events have occurred rarely in patients taking CELEBREX. Cases reported only in the post-marketing experience are indicated in italics. ***Cardiovascular:*** Syncope, congestive heart failure, ventricular fibrillation, pulmonary embolism, cerebrovascular accident, peripheral gangrene, thrombophlebitis, *vasculitis;* ***GI:*** Intestinal obstruction, intestinal perforation, gastrointestinal bleeding, colitis with bleeding, esophageal perforation, pancreatitis, ileus; ***Liver and biliary system:*** Cholelithiasis, *hepatitis, jaundice, liver failure;* ***Hemic and lymphatic:*** Thrombocytopenia, *agranulocytosis, aplastic anemia, pancytopenia, leukopenia;* ***Metabolic:*** *Hypoglycemia;* ***Nervous system:*** Ataxia, suicide; ***Renal:*** Acute renal failure, *interstitial nephritis;* ***Skin:*** *Erythema multiforme, exfoliative dermatitis, Stevens-Johnson syndrome, toxic epidermal necrolysis;* ***General:*** Sepsis, sudden death, *anaphylactoid reaction, angioedema.*

OVERDOSAGE

Symptoms following acute NSAID overdoses are usually limited to lethargy, drowsiness, nausea, vomiting, and epigastric pain, which are generally reversible with supportive care. GI bleeding can occur. Hypertension, acute renal failure, respiratory depression and coma may occur, but are rare. Anaphylactoid reactions have been reported with therapeutic ingestion of NSAIDs, and may occur following an overdose. Patients should be managed by symptomatic and supportive care following an NSAID overdose. There are no specific antidotes. No information is available regarding the removal of celecoxib by hemodialysis, but based on its high degree of plasma protein binding (> 97%) dialysis is unlikely to be useful in overdose. Emesis and/or activated charcoal (60 to 100 g in adults, 1 to 2 g/kg in children) and/or osmotic cathartic may be indicated in patients seen within 4 hours of ingestion with symptoms or following a large overdose. Forced diuresis, alkalinization of urine, hemodialysis, or hemoperfusion may not be useful due to high protein binding.

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THINGS YOU WANT TO KNOW

Ask Us

TELL US

How did this SUV get into such a hairy situation?

Think you know the answer? Go online to nationalgeographic.com/ngm/tellus/0110 and test yourself, or read it here next month.

September Answer The boulder is a concretion of calcite-cemented sandstone that endured while surrounding sandstone eroded. It protected the sandstone below it, forming a pedestal.

NATIONAL GEOGRAPHIC PHOTOGRAPHER SAM ABELL

THE ANSWER PLACE

Our Research Correspondence staff responds to questions from curious readers.

Q If I'm looking at a full moon, a new moon, or just a sliver, is everyone around the world seeing the same phase I am?

A Yes. Phases of the moon occur at the same time no matter where an observer is standing.

Q Does the Statue of Liberty wear shoes?

A Lady Liberty wears 25-foot-long sandals, the equivalent of a woman's shoe size 879.

Q Who first created a system of longitude and latitude? Who set it down as a standard?

A Hipparchus (ca 190-120 B.C.), a Greek astronomer and mathematician, is credited with being the first to designate positions on Earth using latitude and longitude. He devised the system, based on astronomical observations, of superimposing an imaginary grid onto the planet. An 1884 international conference in Washington, D.C., chose the line of longitude passing through the Royal Observatory in Greenwich, England, as the prime meridian, the point from which all other meridians are calculated.

Q When do wildebeests migrate through the Serengeti?

A The wildebeests of Africa's Serengeti Plain travel in vast herds from place to place as the seasons change and food supplies of grasses and other plants are exhausted. They move clockwise through Serengeti National Park in Tanzania and the Masai Mara National Reserve in Kenya.

MORE INFORMATION

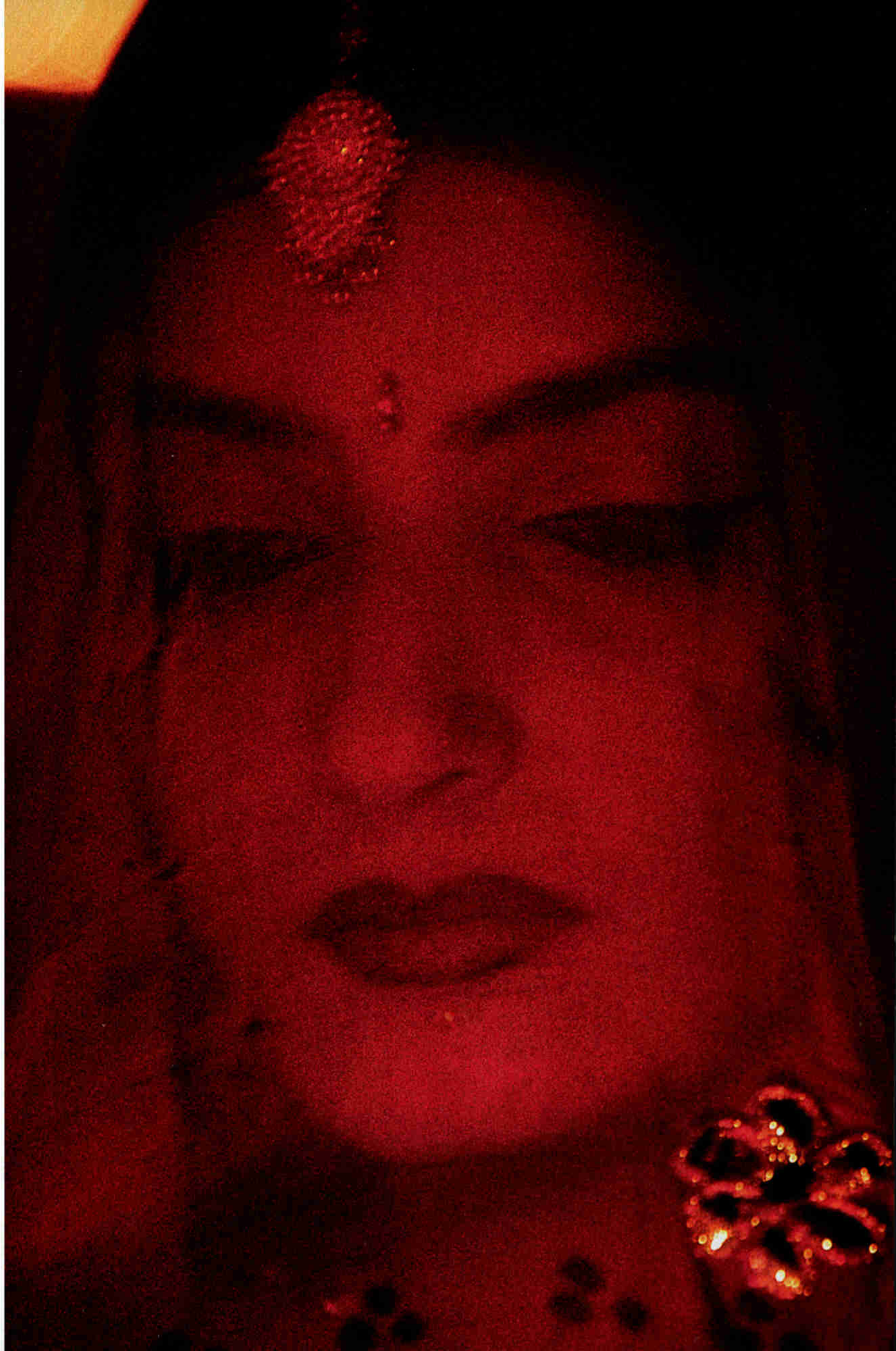
Send questions to **Ask Us, National Geographic Magazine, PO Box 96095, Washington, DC 20090-6095** or via the Internet to **ngsaskus@nationalgeographic.com.** Include name, address, and daytime phone number.

Armored technician Chuck Searcy, Jr., handles one of 39 volatile 7,000-watt xenon lamps atop the Luxor pyramid on the Las Vegas Strip. Touted as the world's brightest light, the Sky Beam is strong enough to read a book by—ten miles out in space. Under high pressure, xenon, a gas, emits a white, sunlike light when an electric current is applied to it. The gaudy radiance of the Strip comes mostly from the gas neon. First used in a light in 1910, neon had revolutionized advertising displays by the mid-20th century.

By Joel Achenbach Photographs by Joe McNally

Light reveals the world to us. Body and soul crave it. Light sets our biological clocks. It triggers in our brains the sensations of color. Light feeds us, supplying the energy for plants to grow. It inspires us with special effects like rainbows and sunsets. Light gives us life-changing tools, from incandescent bulbs to lasers and fiber optics. Scientists don't fully understand what light is or what it can do. They just know that it will illuminate our future.

The Power of Light



Candlelight casts an aura of mystery and beauty around a young woman celebrating the Hindu festival of Diwali in Jaipur, India. Buildings and waterways are lit with candles and oil lamps—the earliest forms of artificial lighting after campfires.

THERE HAS BEEN LIGHT from the beginning. There will be light, feebly, at the end. In all its forms—visible and invisible—it saturates the universe. Light is more than a little bit inscrutable. Modern physics has sliced the stuff of nature into ever smaller and more exotic constituents, but light won't reduce. Light is light—pure, but not simple. No one is exactly sure how to describe it. A wave? A particle? Yes, the scientists say. Both.

It is a measure of light's importance in our daily lives that we hardly pay any attention to it. Light is almost like air. It's a given. A human would no more linger over the concept of light than a fish would ponder the notion of water.

There are exceptions, certain moments of sudden appreciation when a particular manifestation of light, a transitory glory, appears—a rainbow, a sunset, a pulse of heat lightning in a dark sky, the shimmering surface of the sea at twilight, the dappled light in a forest, the little red dot from a professor's laser pointer. Stained glass in a church, backlit by a bright sky. The flicker of a candle, flooding a room with romance. The flashlight searching for the circuit breakers after a power outage.

Usually, though, we don't see light, we merely see *with* it. You can't appreciate the beauty of a rose if you ponder that the color red is just the brain's interpretation of a specific wavelength of light with crests that are roughly 700 nanometers apart. A theatrical lighting director told me that she's doing her job best when no one notices the lights at all. Her goal is to create an atmosphere, a mood—not to show off the fancy new dichroic filters that create colors of startling intensity.

As someone whose understanding of light pretty much began and ended with the flipping of switches, I worried that a story about light would be rather ethereal and esoteric. Surely there wouldn't be anything resembling breaking news on the light beat. Wrong!

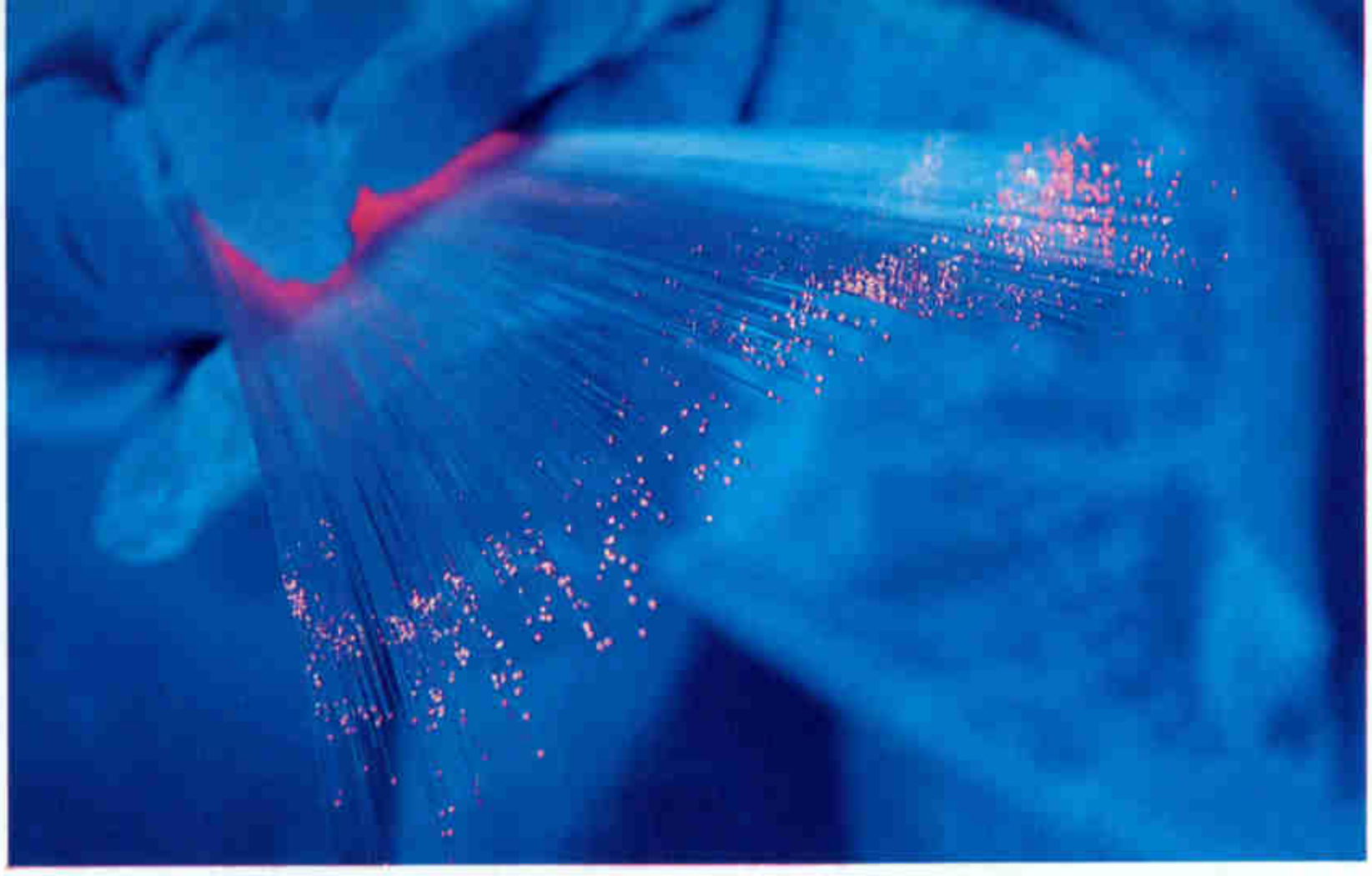
Try an Internet search under the keyword "photonics." A photon is what you call light when it's behaving like a subatomic particle. Photons, it turns out, are a hot commodity. They are replacing electrons—we know them from grade school as the negatively charged particles that orbit the nuclei of atoms—as the favorite tool of modern industry for transmitting information.

Light is now used for everything from laser eye surgery to telephone technology. The potential military applications of light are straight out of science fiction, and within a decade light may be the preferred weapon for zapping hostile missiles out of the sky. Light could even become the preeminent power source for long-distance space travel. The spaceship would have an ultrathin sail to catch the "wind" of light beamed from an Earth-based laser. In theory such a craft could accelerate to a sizable fraction of the speed of light—without carrying fuel.

The more you look at the topic, the more you realize that our lives are built around light, that our daily existence is continuously shaped—and made vivid—by that ambiguous stuff that dates from the beginning of time. From our technology to our spirituality, we are creatures of light.

Light permeates our reality at every scale of existence. It's an amazing tool, a carrier of beauty, a giver of life.

Lightning's naked energy streams from charged terminals on a Van de Graaff generator in Boston's Museum of Science. The eerily lit operator calls to mind *Frankenstein,* the early 19th-century novel that imagined an electric spark could reanimate a body. By the mid-1800s scientists realized that light and electricity were both waves of electromagnetic energy.



Modern magic wands, fiber-optic strands from Lucent Technologies, when pulsed with infrared light, could each transmit ten million phone conversations at once. Taking a big step in manipulating light, physicist Lene Hau (below) of Harvard University used a superchilled gas to stop a laser beam traveling—like all light—at 186,282 miles a second.

One question won't seem to go away: What *is* light, exactly? I got a piece of the answer from the world's largest laser, the National Ignition Facility. NIF is under construction at the Lawrence Livermore National Laboratory about an hour east of San Francisco. The laser is actually 192 lasers in collusion—or perhaps one should say collision. The 192 individual beams of light, grouped in bundles of four, will travel the length of a hulking building 700 feet long and 400 feet wide. Entering a switchyard of mirrors, each bundle will ricochet and shoot through one of 48 portals of the target chamber. The chamber is the star attraction of the facility. It's 30 feet in diameter, weighing a million pounds. The portals give it a dimpled surface that brings to mind an enormous golf ball from outer space.

Inside the chamber the laser beams will crash into a gold-plated cylinder, slightly smaller than a bite-size Tootsie Roll, with a gas-filled pellet inside. The gases in the pellet, under the pressure of all this light, will compress to the point where they achieve nuclear fusion.

"The goal is to create a miniature star in the laboratory," said Ed Moses, the NIF project manager.

This is, to say the least, an ambitious project, and its 3.4-billion-dollar price tag has not eluded critics. They note that NIF may never actually produce a fusion reaction. Technologically, this is not a slam dunk. No one has ever successfully used light to drive together atomic nuclei. The big laser will let scientists study thermonuclear reactions without detonating a bomb. A long-term goal of NIF is to clear a technological path toward a source of cheap, inexhaustible, pollution-free electricity.

"NIF will produce more power in a one-nanosecond laser pulse than all the power generated in the rest of the world at that moment," said Vaughn Draggoo, the physicist who showed me the target chamber.

How is it, I asked Moses, that light is such a useful source of energy?

"Because you can compress a lot of light's energy in a very small point," he said. Children, he noted, discover this when they play with a magnifying glass on a sunny summer day.

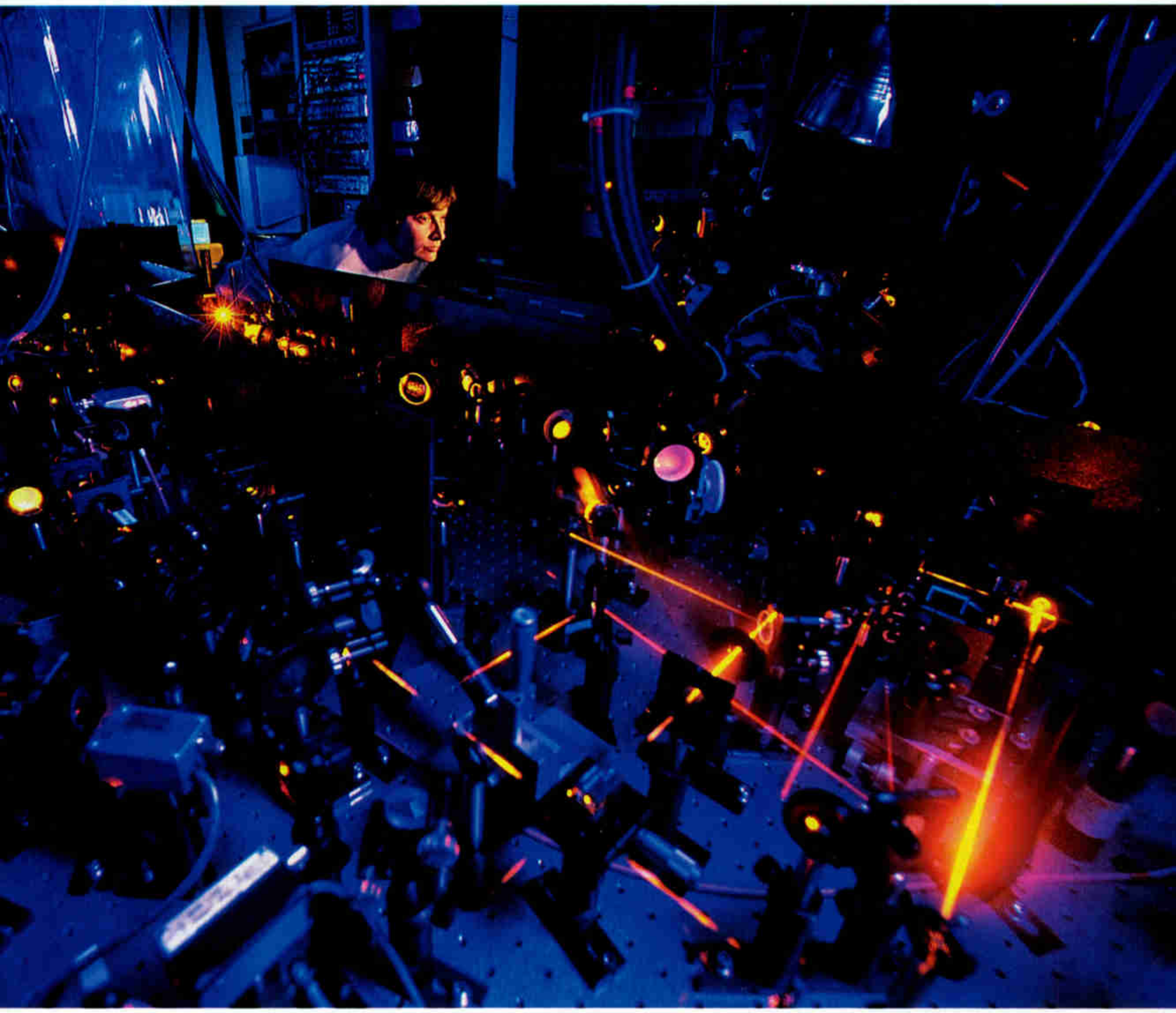
Here we come to one facet of the miracle of light. It has no volume. And photons have no charge, so in the process of being concentrated into a very small space, they don't repulse each other as negatively charged electrons do. (NIF will fit 4×10^{24} photons into the target capsule.) "They don't bother one another" is the way Moses puts it.

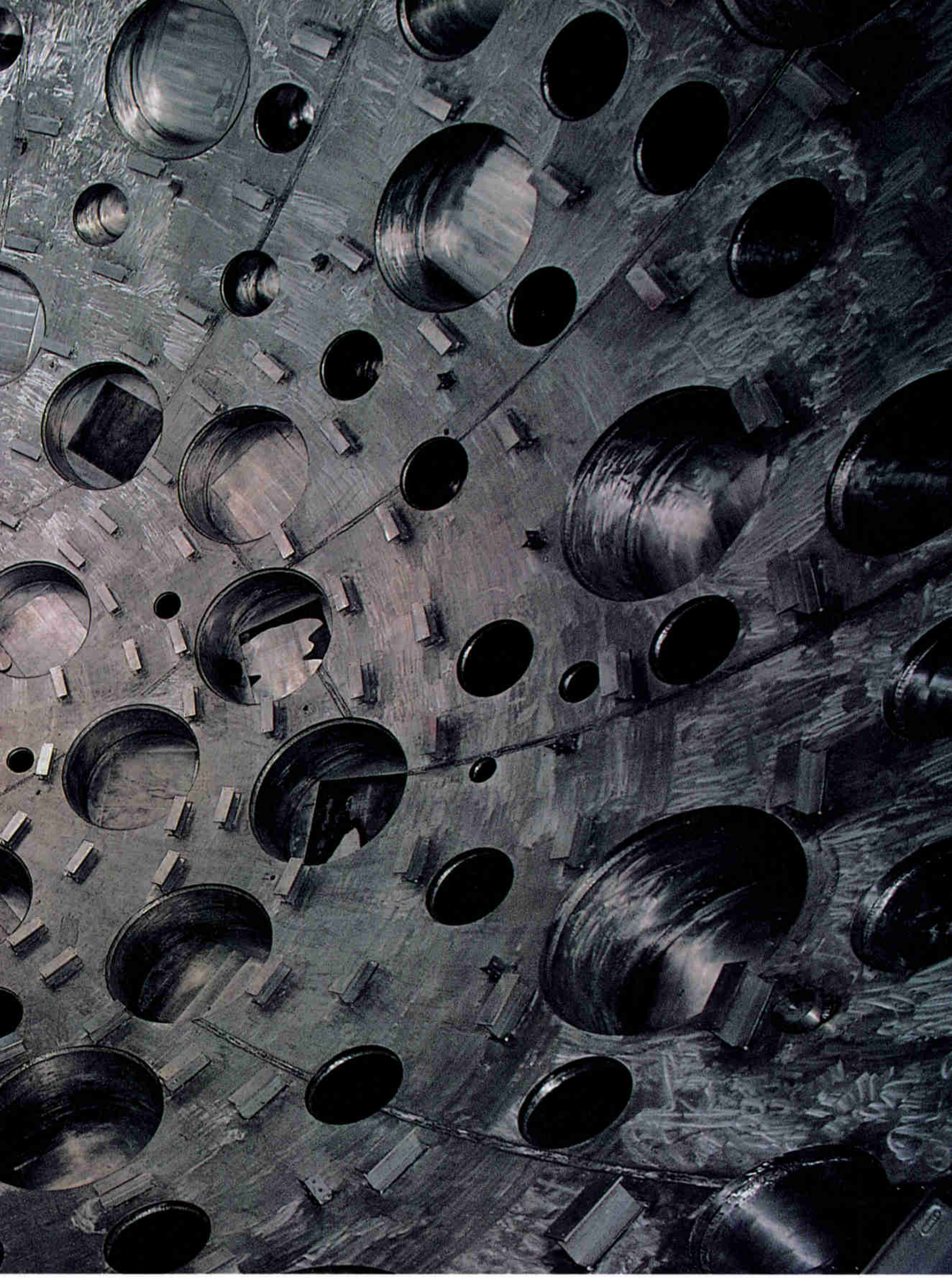
How many angels of light can dance on the head of a pin? In theory, an infinite number.

AS HARD AS IT IS TO UNDERSTAND LIGHT, the ancients had it that much harder. Lacking scientific instruments, they could probe the nature of light only with their inventive minds. "Light is the activity of what is transparent," was one of Aristotle's rather opaque declarations. This transparency was an essential property of various substances; when activated by sun or fire, it produced light and color.

The fifth-century B.C. philosopher and poet Empedocles had the brilliant intuition that light is a streaming substance emitted by the sun and that we are not conscious of its movement because it moves too fast. But he also subscribed to the notion of the "fire within the eye," comparing the eyes to lanterns. Many Greeks, including Plato and Euclid, shared this belief that the eyes produce some kind of visual ray. It explained the curious fact that sometimes we look in the direction of an object but fail to notice it immediately. The ray, it was surmised, must strike the object directly before it can be seen. Aristotle was among those to point out that if this were true, we'd be able to see in the dark.

A thousand years ago the Arab scientist Alhazen argued that the pain





Creeping like a fly on a wall, Vaughn Draggoo inspects the huge target chamber at the National Ignition Facility in California, a future test site for light-induced nuclear fusion. Beams from 192 lasers will be aimed at a pellet of fusion fuel to produce a controlled thermonuclear blast.

we feel when we look at the sun is evidence that the light is entering the eye and not the other way around. Centuries later Leonardo da Vinci realized that the eye is akin to the camera obscura, pioneered by Alhazen, in which light passes through a pinhole into a darkened room and casts an inverted image of the exterior world onto a wall. Descartes later did a rather dramatic examination of the eyeball of an ox, scraping away the back of the eye and peering through it. He saw that the eye captures an inverted, upside-down image of the world. Why doesn't the world look upside down? Because our minds correct the image. Sight has both a physical and psychological element.

Light soon passed through the laboratory of Isaac Newton and never looked the same again. In the 1660s Newton demonstrated that white light is composed of all the colors of the spectrum. Using a prism, he broke sunlight into a rainbow, then later used a second prism to cohere the colors back into white light.

"Whatever light be," he told the Royal Society in 1675, "I would suppose, it consists of Successive Rays differing from one another in contingent circumstances, as bigness, forms, or Vigour, like as the Sands on the

Visually impaired children swarm around a light table to learn shapes and colors at Marquette School in Detroit, Michigan. "The kids crave light so much," says Carol Walker, who works with 30 students in the Detroit public school system. "The light levels in most homes are inadequate for them. They need more light to stimulate their vision."

Light passed through the laboratory of Isaac Newton and never looked the same again.

Shoar, the Waves of the Sea, the faces of men, and all other naturall things."

Newton believed that light was particulate—"multitudes of unimaginable small and swift Corpuscles of various Sizes, Springing from Shining bodies at great distances one after another." Newton was such a giant on the scientific landscape that his rivals had little luck pushing the theory that light is a wave. The wave theory did not begin to rebound until the titans of 19th-century science joined the battle to understand light and overwhelmingly came down on the side of waves. It was James Clerk Maxwell, a Scot, who in the 1860s made one of the most essential breakthroughs. He had been studying electricity and magnetism and realized that they propagated through space at—coincidence?—the speed of light. Light, he concluded, is an "electromagnetic" wave.

The particle versus wave debate wound up with a kind of truce, governed by quantum mechanics: Light is produced by changes in the energy level of electrons. Light moves through space as a wave, but when it encounters matter it behaves like a particle. It simply doesn't fit into one of our neat little categories. "Light, indeed, is different from anything else we know," writes Sidney Perkowitz, a physicist at Emory University and the author of *Empire of Light*. The era of permanent uncertainty began in 1900, when Max Planck's experiments with heat radiation implied that light pounded against matter in discrete chunks—quanta, he called them—like bullets from a machine gun. This seemed contrary to Maxwell's equations, and Planck was reluctant to believe it.

Enter Albert Einstein. It's common knowledge that Einstein, in promulgating the special theory of relativity, destroyed the mechanical, deterministic Newtonian universe. He achieved this theoretical breakthrough by thinking about . . . yes, light. Einstein did "thought experiments," and in one he asked what would happen if you could ride a beam of light and look at an adjacent beam. Wouldn't the adjacent beam of light appear motionless? Maxwell's equations didn't seem to allow light to slow down or stop when moving through space. Einstein's answer—that light's speed is constant for all observers regardless of their own velocity—obliterated the classical conception of space and time.

The groundwork was laid for Einstein by a famous experiment in 1887 by American scientists Albert Michelson and Edward Morley. The Earth, according to the orthodoxy of the time, moved through a fixed ether that filled space. No one had ever detected this ether, but common sense required its existence. Michelson and Morley set out to detect it by measuring the speed of light when light beams traveled with, and perpendicular to, the motion of the Earth. They expected light to show the effects of the "current" of this ether as Earth hurtled along. It didn't. The speed of light was the same no matter its direction. Scientists, including Michelson and Morley, were aghast and hoped that the results were simply wrong. Einstein accepted them. There is no ether, he said. There's no absolute location in space. There isn't even any absolute time.

I will confess that relativity makes my head spin. A beam of light from the headlamp of a speeding locomotive ought to move faster—says common sense—than the beam from a stationary flashlight. It doesn't. And there's nothing anyone can do about it.

Einstein's relativity presents all manner of head-scratching implications. It reveals that as objects approach the speed of light, time slows down. At the speed of light itself, time stops.

This fact can help us think about the journeys made by starlight and

Sun

Light to Sight

Our blazing star floods the Earth with sunlight and activates human vision. Nearly half the energy that radiates into space from the sun oscillates at wavelengths that our eyes respond to and process into sight and color.

Ancient Greeks thought that our eyes acted as lanterns, sending out rays that made objects visible when struck. This concept amazingly held for more than 1,500 years until the Arab scholar Alhazen about A.D. 1000 made convincing arguments otherwise.

A giant advancement in the study of light came in the 1660s, when Isaac Newton's experiments with prisms revealed that white light is composed of all the colors of the visible spectrum, a revolutionary notion at the time. Scientists later established that colors correspond to specific wavelengths.

Each of our eyes comes equipped with around 125 million sensors that enable us to absorb light reflected from our surroundings.

ART BY CHRISTOS MAGGANAS

Electromagnetic spectrum

Shortwave energy
Radiation with wavelengths below 400 nanometers includes the harmful frequencies of ultraviolet, x-rays, and gamma rays. Earth's atmosphere absorbs x-rays and gamma rays.

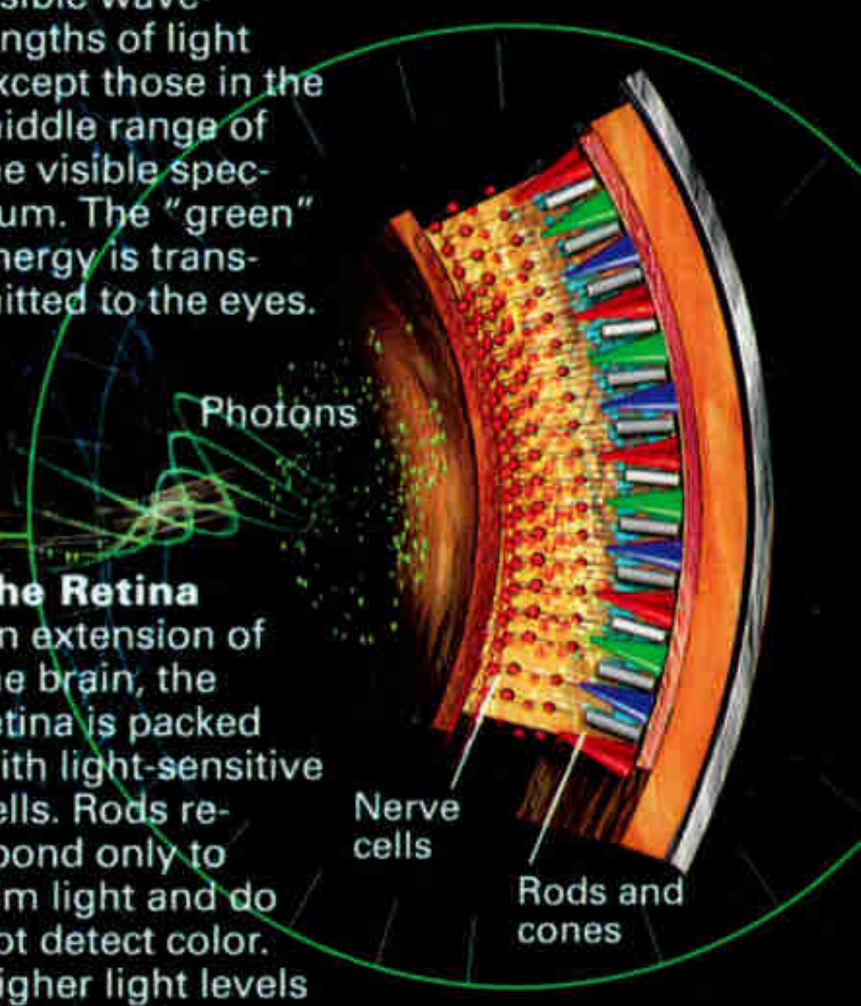
Green glass

Visible spectrum
Radiation in wavelengths from 400 to 750 nanometers penetrates Earth's atmosphere in amounts roughly equal to the invisible long wavelengths of the electromagnetic spectrum. Visible wavelengths are sensed as a band of colors—violet to deep red.

Long-wave energy
Invisible rays above 750 nanometers include infrared, microwave, and—at the far end of the electromagnetic spectrum—radio waves, which stretch for miles.

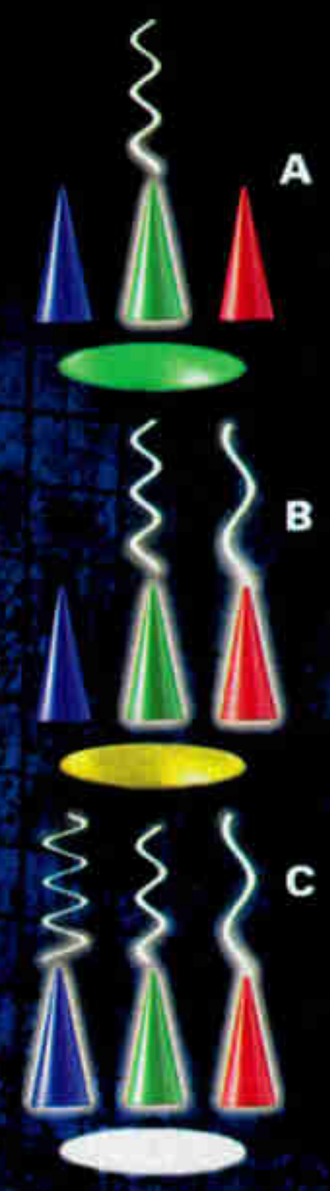
Seeing Color

Incoming Light
A sheet of green glass absorbs all visible wavelengths of light except those in the middle range of the visible spectrum. The "green" energy is transmitted to the eyes.



The Retina
An extension of the brain, the retina is packed with light-sensitive cells. Rods respond only to dim light and do not detect color. Higher light levels stimulate cones to sense wavelengths of color.

Color Sensation
Cones come in three types, loosely identified as blue, green, and red, each with a peak sensitivity to a specific range of wavelengths. A wavelength of 530 nanometers, for instance, will mainly excite the green cones (**A**). Adding longer wavelengths will stimulate both red and green cones to make yellow (**B**). Often colors result from such combined responses. If all three types are stimulated, the result is white (**C**).



However, as physicist Sidney Perkowitz writes, "We see the glory of light as through a narrow slit." Humans are blind to most wavelengths of light, including long radio waves as well as damaging short-wave radiation like ultraviolet, x-rays, and gamma rays.

The passage of light from the sun to the eye and brain requires that light act both as a wave and as a particle. Light is best understood as a wave when it moves through space. Light waves reaching the eye are bent and focused as they pass through the cornea and lens to reach the retina with its dense mat of rods and cones. When encountering these light-sensitive cells, light acts as a particle of energy, or photon. The photons interact with pigments in the rods and cones, triggering neural impulses to the brain, which analyzes and converts them to sensations of color. Experts believe humans can discern as many as ten *million shades* of color.

galaxylight and quasarlight across cosmic distances. We use the term light-year to express a unit of distance (about six trillion miles). But if you were the light itself—if you could be the photon—you'd experience no time. That long journey would be instantaneous.

WHAT WE CALL LIGHT is really the same thing—in a different set of wavelengths—as the radiation that we call radio waves or gamma rays or x-rays. But in practice scientists often use the term "light" to mean the portion of the electromagnetic spectrum in the vicinity of visible light. Visible light is unlike any other fundamental element of the universe: It directly, regularly, and dramatically interacts with our senses.

Our eyes each have about 125 million rods and cones—specialized cells so sensitive that some can detect a mere handful of photons. "About one-fifth of your brain does nothing but try to deal with the visual world around you," says Sidney Perkowitz. The position of the eyes, semiprotected in the case of the skull close to the brain, is testament to the importance of visual data.

Light offers high-resolution information across great distances (you can't hear or smell the moons of Jupiter or the Crab Nebula). So much information is carried by visible light that almost everything from a fly to an octopus has a way to capture it—an eye, eyes, or something similar.

It's worth noting that our eyes are designed to detect the kind of light that is radiated in abundance by the particular star—the sun—that gives life to our planet. Visible light is powerful stuff, moving at relatively short wavelengths, which makes it biologically convenient. To see long, stretched-out radio waves, we'd have to have huge eyes, like satellite dishes. Not worth the trouble! Nor would it make sense for our eyes to detect light in the near infrared (though some deep-sea shrimp near hot vents do see this way). We'd be constantly distracted, because any heat-emitting object glows in those wavelengths. "If we were seeing infrared," physicist Charles Townes told me one day, "all of this room would be glowing. The eye itself is infrared—it's warm. We don't want to detect all of that stuff."

There is also darkness in the daytime—shadows. There are many kinds of shadows, more than you probably realize—certainly more than I realized until I consulted the shadow expert. I found him at the end of a long and winding drive through Topanga Canyon, just up the coast from Santa Monica, California.

David Lynch is an astronomer. He's also the co-author of a book called *Color and Light in Nature*, in which I discovered something

Moods darken when the sun goes into exile during winter in the northern Russian village of Lovozero. Ten in the morning looks almost like midnight (above). A shortage of light can unleash the winter blues, diagnosed as seasonal affective disorder (SAD). Medicating his blues with alcohol, a young man in nearby Murmansk ends up in the drunk tank (left).

about shadows that I'd never thought of before. Lynch points out that a shadow is filled with light reflected from the sky—otherwise it would be completely black. Black is the way shadows on the moon looked to the Apollo astronauts, because the moon has no atmosphere and thus no sky to bounce light into the unlit crannies of the lunar surface. Only the faint glow of earthshine filled the shadowy recesses.

Lynch is a man who, when he looks at a rainbow, sees details that elude most people. He knows, for example, that all rainbows come in pairs, and he always looks for the second rainbow—a faint, parallel rainbow, with the colors in reverse order. The intervening region is darker. That area has a name, wouldn't you know: Alexander's dark band.

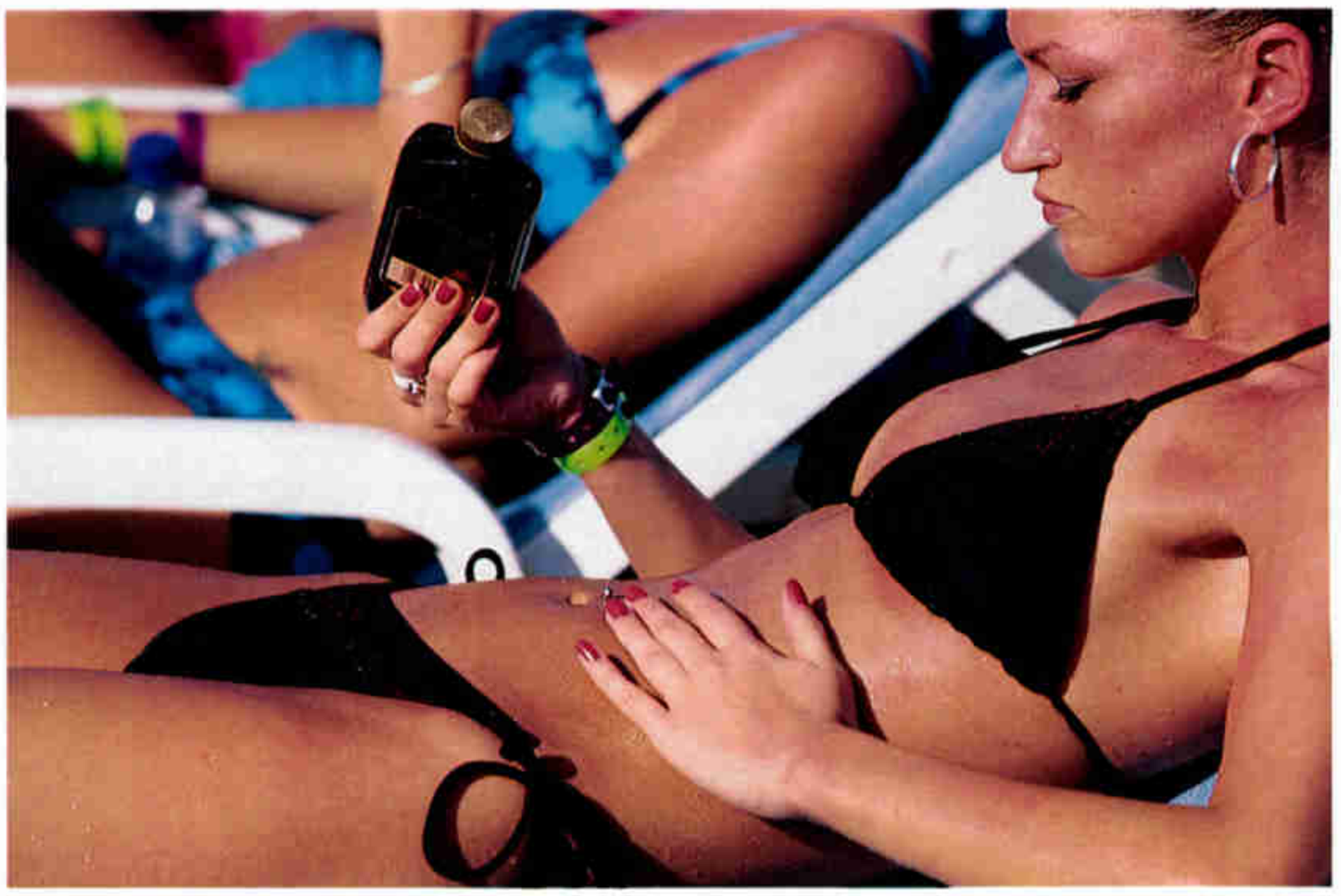
We sat on Lynch's deck and drank orange juice squeezed from fruit freshly yanked from trees in his backyard. The view was spectacular, the canyon opening like a great basin, a mountain ridge obscuring the Pacific and running for half a dozen miles to Santa Monica.

"The reason those mountains over there look a little blue," Lynch continued, "is because there's *sky* between here and those mountains. It's called airlight."

Make-believe summer lasts for a minute or two as kindergarten children in sunless Lovozero bathe in ultraviolet light. Brief exposure to UV radiation provides the children with vitamin D, normally supplied by sunlight. The "sunshine vitamin" strengthens young bones.


SunBoard
SunBoard
SunBoard

A human would no more linger over the concept of light than a fish would ponder the notion of water.



The sky is blue because the molecules in the air scatter blue light more readily than they scatter red, orange, yellow, and green. We see distant mountains through a mass of blue sky—hence the Blue Ridge and (thanks to poetic license) "purple mountain majesties."

LAS VEGAS IS A MULTITUDE OF COLORS—a place that takes light seriously and can't seem to emit enough of it. The Strip is more dazzling by the year. The casinos no longer advertise themselves with mere neon-lit roadside marquees but rather have turned their entire structures into eyeball-popping orgies of illumination. "Now the whole building is a sign," says longtime sign dealer Ken Moultray.

The entirety of the MGM Grand glows emerald. Fiber optics pulse light to the tower of the Stratosphere. The vertical neon stripes adorning the Rio are visible from distant mountains.

The Luxor Resort and Casino is a pyramid and, perversely, remains almost entirely dark at night, a massive black presence dramatically highlighted by the golden glass of the Mandalay Bay Resort next door. Instead of dressing itself in countless little bulbs or immersing itself in floodlights, the Luxor aims its Sky Beam—said to be the brightest light on the planet—straight into space.

I followed John Lichtsteiner, technical manager of rides and attractions at the Luxor, up three metal ladders onto the catwalk at the pyramid's peak to see the 39 xenon lamps, 7,000 watts each, that create the Sky Beam. A sign warns that the lights, each about the size of a washing machine, are "extremely volatile" and can explode if jarred or bumped.

Lichtsteiner explained that before a computer turns on the Sky Beam each night, strobe lights flash for 30 seconds. "We don't want to surprise any pilots," he said.

He pressed a button on a digital console to illuminate one of the lamps. Its light was so bright that when I put my notebook into the beam, I had to look away quickly. My pen strokes vanished, and all I could see was a rectangle of blinding white light.

We climbed above the lamps to the very tip of the pyramid. Vegas sprawled for miles in every direction. In the daytime the place is rather

Too busy to tan outdoors, college freshman Lezlie Brackett spares 20 minutes to soak up ultraviolet light at Darque Tan in Austin, Texas. Dermatologists warn that prolonged, unprotected exposure to UV rays greatly increases the likelihood of skin cancer. Covering up, however, holds no appeal for sun worshipers on spring break in Cancún, Mexico.

washed out, the colors flattened. The sparkle, the glitter, the almost hallucinatory colors of Vegas at night are obliterated in the white light of the desert sun.

"Now there's a lamp," I said, nodding toward that natural beacon in the sky.

Later I went to see a show at the Bellagio. Walking into the theater, I was mesmerized by the red curtain. It looked . . . really red. It also looked heavy, velvety, like a curtain in a baroque theater.

What I didn't know until later was how much my eyes were being fooled by clever lighting. The lighting designer, Luc Lafortune, uses two different sets of lights—a bright red aimed straight at the curtain and a softer red shining in from the side—to create a sense of depth and heaviness in the fabric. The curtain is actually made of a lightweight fabric that enables the stage director to whisk the whole thing aside in a flash.

Jeanette Farmer, lighting director for the show, showed me around backstage. She keeps track of 2,000 computer-controlled lights and 1,695 dimmers. She can do much of her work at a console—no more climbing ladders to change filters. Little motors in the lamps do all that. She no longer uses just single-gel filters over white lights to create yellow or red or blue. State-of-the-art stage lighting uses dichroic filters, pieces of glass with mineral coatings. These provide a purer, more intense light—the kind that made the curtain look like shimmering red velvet. The old gel filters let in a lot of "noise," while the dichroics select a very narrow slice of the spectrum.

Farmer gives credit where it's due—to Isaac Newton, for realizing that white light is composed of different colors. "In so many ways he laid the groundwork for all of us," she said. "He knew what the deal was."

"THIS IS A VERY PURE, STRAIGHT BEAM." Charles Townes was showing me a helium-neon laser in his laboratory at the University of California at Berkeley. He has hundreds of lasers, including some that arrive in the mail as gifts, newfangled lasers smaller than matchboxes, green lasers soothing to the eye—all the various descendants of a gadget he invented in the 1950s. He and his brother-in-law Arthur Schawlow developed the techniques

Daybreak illuminates the ancient structure of Stonehenge in early summer on Britain's Salisbury Plain. Plotting the sun's position through its stone portals, early astronomers charted the passage of seasons. Light frees energies inside the body, says Gerry Bostock, an Aboriginal healer in Australia. Using a quartz crystal, Bostock focuses light on a patient's pituitary gland to relax her and, he says, remove energy blocks.

that led to what was called "light amplification by stimulated emission of radiation." (Obviously the acronym would be easier for everyone to say.)

Light normally spreads out rapidly in all directions; a laser coheres the light in a narrow beam. The key to producing this beam is the basic atomic principle that says that photons—and now we're back to describing light as particles—can be absorbed or emitted by atoms.

When an electron changes from a high-energy, or excited, state to a low-energy state, its atom will emit a photon. A laser exploits this process. It starts with a crystal or other medium whose atoms are prone to excitement. These atoms are slammed with light, causing their electrons to do a little dance. When they calm down, they release excess energy as photons. Those photons, in turn, incite more electron dancing, which creates more photons—a chain reaction. It is physics, not magic, that causes more light to come out than went in.

The arrival of the laser was heralded by certain newspapers as the start of a new era of military death rays, the killer cousins of the Martian Heat-Ray in *The War of the Worlds.* But a half century ago Townes and Schawlow weren't actually sure what could be done with their invention—or with its prototype, the maser (which used microwaves instead of visible light). They just knew they'd figured out a nifty way to make light shine strong and straight.

"People used to kid me, 'Lasers are a solution looking for a problem,'" Townes said.

He thinks about that every time he goes to the checkout line at the grocery store, where light is used to scan the price of every product. A laser reads the CD in his CD player. Surveyors used a laser to gauge the precise property lines on Townes's New Hampshire farm. When he makes a long-distance phone call, his words are transmitted by laser light along a fiber-optic cable.

It's hard to overstate the usefulness of a tool that makes light shine straight. Laser beams fired from the Earth have bounced off mirrors left on the moon by Apollo astronauts, allowing scientists to measure the moon's distance—across more than 225,000 miles—to within half an inch. Laser surgery corrects faulty vision in an increasingly routine procedure.

"When a friend comes to me and says laser surgery saved his eyesight, that's a very emotional thing," Townes says.

"When a friend comes to me and says laser surgery saved his eyesight, that's a very emotional thing."

"LIGHT IS A UNIVERSAL PROBE," says Michael Hart, a physicist. He was showing me around the National Synchrotron Light Source, in Upton, New York. Built in the early 1980s, it's a sprawling device of comical complexity and is, Hart says, the "most used light source" in the world.

The synchrotron uses magnets to guide electrons around a ring that's about the size of a basketball court. Every time an electron turns a corner, so to speak, it emits a photon. The photons fly away from the ring in what are called beamlines. There are 92 beamlines in operation on two synchrotron rings, and each one has been customized with a dazzling array of mad-scientist gadgetry—dials, gauges, valves, pumps, vacuum chambers, optical sensors, wires, pipes, and lots of slapped-on aluminum foil. The different beamlines are used by researchers from universities, government labs, and places like IBM, Bell Labs, and Exxon.

What do they do with the light? Mostly they look at things—as you'd expect. They look at impurities in materials. They examine the porosity of rocks extracted from the Earth by oil drillers. Eight of the beamlines are being used to study the three-dimensional structure of proteins in an effort to decipher some of the secrets of the human body.

For a while one of the beamlines was used for a medical diagnostic procedure called coronary angiography. There was one hitch in doing the examinations: Who would want to sit in front of a giant ray gun that looks as though it could burn a hole through the Earth? The researchers constructed an examination room with a blank wall, with only the tiny nub of the beamline apparatus peeking through.

The photons here range from infrared radiation to x-rays—well beyond the range of visible light. Hart marvels that for so much of human history we perceived the natural world only with visible light, that slice of the electromagnetic spectrum from red to violet. Making use of light beyond the visible realm has allowed scientists to create a new array of images of the reality around us. "We can see a single layer of atoms on a surface," Hart said.

Like everyone else I talked with who deals with light, Hart seemed almost in awe of the power of light. Technology constantly advances, allowing engineers to create ever brighter beams. The general rule, said Hart, is that brightness has increased a hundredfold every five years.

Taking pinpoint aim, surgeon Julia Haller deploys the intense beam of a head-mounted laser to repair a retina. Using advanced laser technology at Johns Hopkins University's Wilmer Eye Institute, Haller wields light to destroy tumors, stop abnormal growth of blood vessels, and seal retinal tears. A laser achieves its power by emitting selected wavelengths traveling in phase with each other.

THE TELECOMMUNICATIONS INDUSTRY loves light. When you visit Lucent Technologies' Bell Labs in Holmdel, New Jersey, you're greeted with a sign saying "Welcome to Photon Valley." There has arisen something almost like a high-tech cult of light in this industry, built around the belief that human beings will increasingly exploit the almost infinite amount of bandwidth found in a light beam.

Kathy Szelag, a vice president with Lucent's Optical Networking Group, told me, "People like my parents think we're in the *Star Wars* part of optical networking. We're really in the crude oil part of optical networking. We're just at the beginning." Her colleague Bob Windeler, an optical-fiber researcher, added, "The amount of information you can put on a fiber more than doubles every year." In theory a single fiber could someday transmit every phone call on Earth simultaneously.

The optimism has been tempered of late by business woes among telecommunication companies, but the technology remains impressive. Take, for example, wavelength division multiplexing. Lasers are used to beam different wavelengths of infrared light down a single fiber. Each wavelength is its own data channel—its own pipe. Right now, a fiber can carry dozens of these channels, but that could become thousands or even millions. "It's as close to a miracle as there is," says Dave Bishop, Lucent's vice president of optical research—sounding very much like all the other light-crazy people I'd talked to.

George Gilder, a conservative political theorist who transformed himself into an influential technology guru, has declared in recent years that light will be the medium of a communications revolution. "You can envision a point where everyone in the world could have his own wavelength," says Gilder. "You'd have one wavelength that connected you to the person you wanted to address in Vienna or Tokyo or Tierra del Fuego, and this wavelength could easily accommodate three-dimensional images. You could have conversations in which you forget within literally seconds that the person is not present. You see a face, the image saturates your own optical capabilities."

He adds, "I believe that light was made by God for communications."

What next for light? What new application will we see? What orthodoxy-busting cosmic information will starlight deliver to our telescopes? Will the rotating disco ball ever make a dance-floor comeback? Above all, you have to wonder: Will we ever fully understand light?

We have spent thousands of years chasing sunbeams, and even if we never quite catch them, we still discover many a marvel in the pursuit. Modern physics, with its paradoxes and uncertainties, emerged from the study of the interaction of matter and light. Modern cosmology, including the stunning revelation that the universe is expanding, came from the scrutiny of faint galactic light. Modern computer engineering may eventually turn to light, crafting devices that, instead of silicon chips, have light beams at their core.

There have been recent headlines about scientists finding ways to make light go faster than the speed of light. This is what science fiction writers and certain overly imaginative folks have dreamed of for decades. If you could make a spaceship that wasn't bound by Einstein's speed limit, you could zip around the universe far more easily.

Lijun Wang, a research scientist at NEC Research Institute in Princeton, New Jersey, managed to create a pulse of light that went faster

Awesome! A storm of colored laser lights flashes over dancers at a rave in Austin, Texas. Scanners, filters, fog machines, and computerized color-mixing help create the mood-enhancing sprays of light. "I want light to touch people," says control board maestro Tim Walsh of Laser Spectacles, Inc. "I want them to say, 'Wow, that's beautiful.'"

than the supposed speed limit. "We created an artificial medium of cesium gas in which the speed of a pulse of light *exceeds the speed* of light in a vacuum," he said. "But this is not at odds with Einstein." Even though light can be manipulated to go faster than light, matter can't. Information can't. There's no possibility of time travel.

I asked Wang why light goes 186,282 miles a second and not some other speed.

"That's just the way nature is," he said.

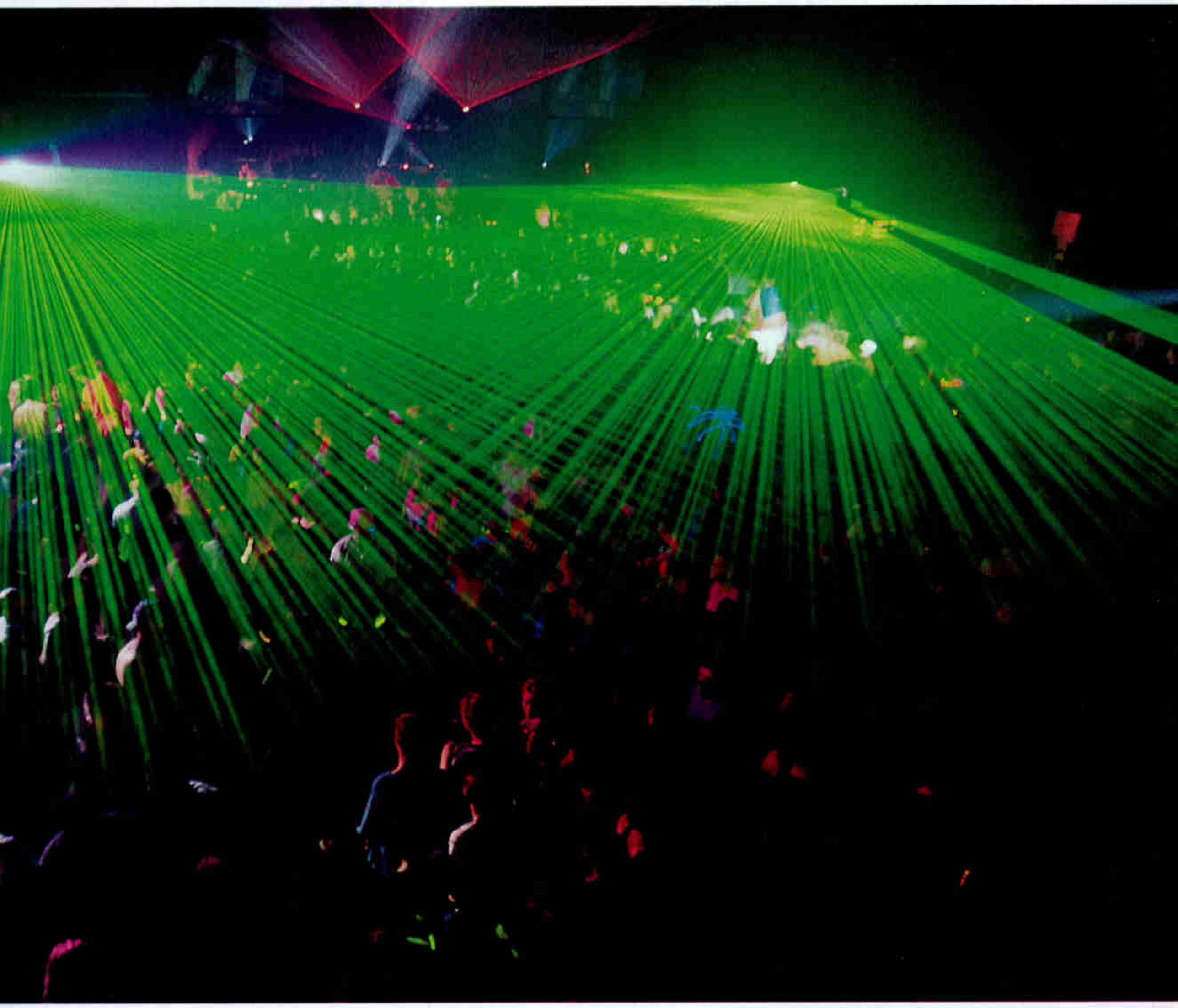
There are scientists who don't like "why" questions like this. The speed of light just is what it is—that's their belief. Whether light would move at a different velocity in a different universe is something that is currently outside the purview of experimental science. It's even a bit out-there for the theorists.

What's certain is that light is going to remain extremely useful—for industry, science, art, and our daily, mundane comings and goings. Light permeates our reality at every scale of existence. It's an amazing tool, a carrier of beauty, a giver of life.

I can't help but say that it has a very bright future.

MORE ON OUR WEBSITE

How do you photograph the intangible? Joe McNally discusses his coverage in Sights & Sounds at **nationalgeographic.com/ngm/0110**.



How many engineers does it take to screw in a lightbulb on top of the Empire State Building? One. It's Tom Silliman of Electronics Research, Inc., who installs safety lights 1,450 feet above New York City. As he works, Manhattan emerges at dawn for another light-filled day. □

NIGHT SHIFT IN THE RAIN FOREST

ARTICLE AND PHOTOGRAPHS BY TIM LAMAN

A wide-eyed tarsier, a tiny forest primate, enjoys a cockroach snack as it forages for food in the dark hours at an Indonesian nature reserve on Sulawesi.

TARSIUS SPECTRUM, TANGKOKO-DUASUDARA NATURE RESERVE

As the day's last light paints the tropical sky, I perch on the side of a cliff on Khao Luk Chang (Baby Elephant Mountain) in Thailand. A few feet in front of me thousands of wrinkled-lipped bats stream out of their cave. Soon they will fan out and gorge on insects in the forest below. Human eyes that work so well during the day are of little use in this world. Out here, hosts of species are supremely adapted for making a living in the dark. Bats with their sonar, tarsiers with their acute hearing and night vision, and civets with their exquisite sense of smell are just a few examples. I wish my senses were a match for these nocturnal creatures. Though limited to my human perception, I do get a little help from technology. With headlamps, strobes, infrared camera traps, and night-vision scopes in my arsenal, I head off into the rain forest after dark. It's as rich in life as it is by day but with an almost completely *different* cast of characters.

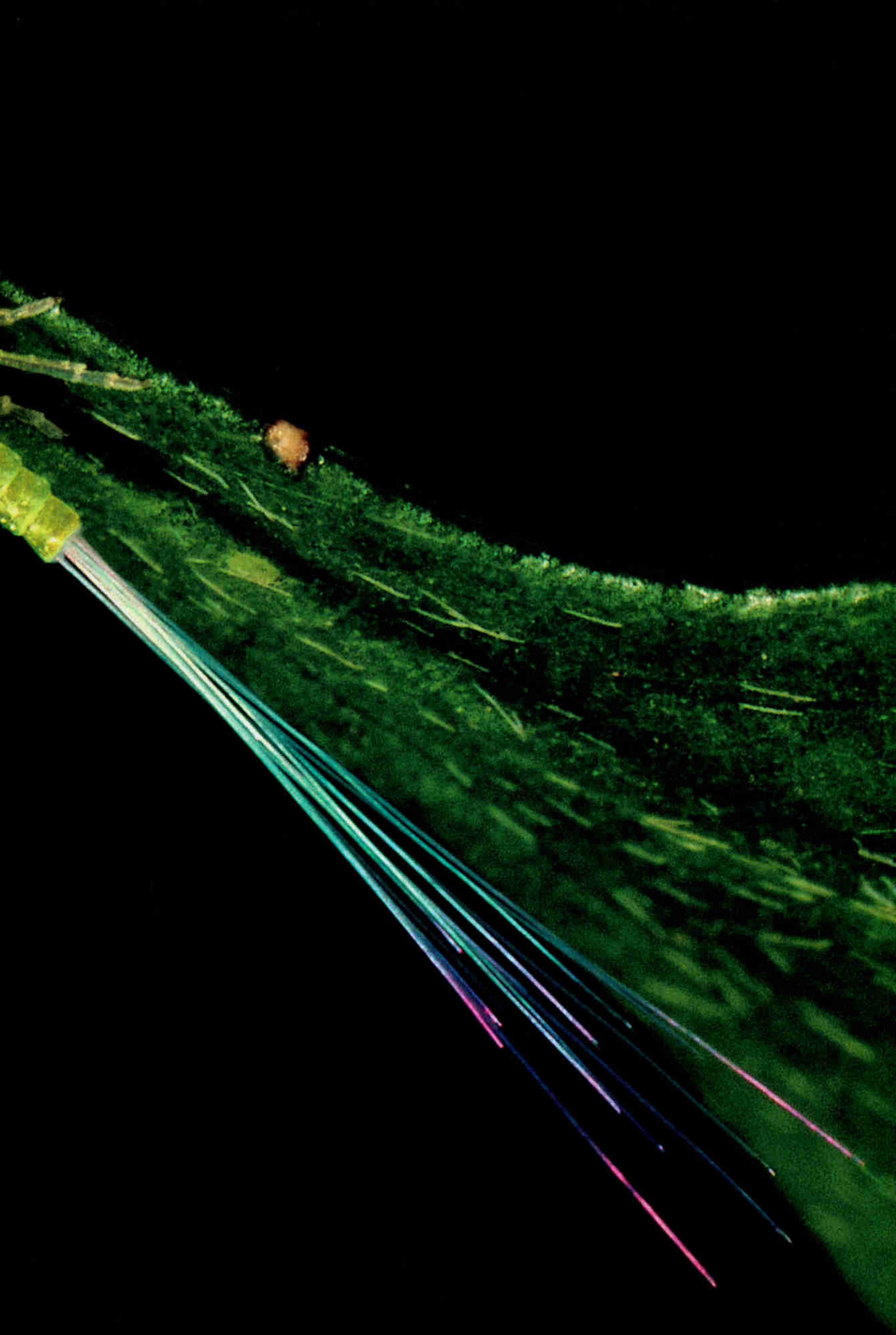
TADARIDA PLICATA, KHAO YAI NATIONAL PARK

LIMACODIDAE, DANUM VALLEY CONSERVATION AREA

I have photographed creatures of the night in rain forests across tropical Southeast Asia, including Thailand, Malaysia, and Indonesia (map). African and South American rain forests host a similarly rich assortment of little-known inhabitants. Of these three equatorial regions, Asia is losing its forests the fastest and has the fewest remaining. In Indonesia alone, illegal logging has led to what one scientific report called a "biological catastrophe."

Whether I am strolling along a forest track, where I spotted this spiky caterpillar chomping on a wild ginger leaf (above), or making an exploratory night climb with colleagues into the top of Borneo's forest canopy of dipterocarp trees (right), the night has many surprises in store for me. Few people have ever experienced them, and unless we protect enough pristine forest, few ever will.

If we act quickly to preserve what remains, generations to come will still be able to appreciate the wonders of the rain forest's night shift.



FULGOROIDEA, DANUM VALLEY (LEFT)

LIBELLULIDAE, DANUM VALLEY (BELOW)

What goes in must come out, but rarely does animal waste look so graceful. This plant hopper nymph (left) feeds on plant juices with a tubelike mouth. The long fibers that appear to form a tail are the waxy residue of sugars discharged after the hopper extracts nutrients from sap. Glands arranged like a spaghetti press push out the filaments, composed of microscopic hollow tubes. These filaments may deter predators, or they may simply break away if a predator tries to grab the false tail.

Whether they have tricky defenses or not, many insects find that night is the safest time. A dragonfly (below) uses the cover of darkness to emerge from its larval skin and dry its wings. It will be able to fly by morning, but several days will pass before its body fully hardens and develops characteristic bright colors.

ECHINOSOREX GYMNURA, DANUM VALLEY (LEFT)

BOIGA SP., DANUM VALLEY (RIGHT)

CUON ALPINUS, KHAO YAI (BELOW)

The night is a time for carnivores of many tastes. As odd as its name, the moonrat (left) is not really a rat but part of the hedgehog family. Although some are black with white markings, those found on Borneo are predominantly white. Their conspicuous coloring and bad odor advertise a repulsive taste to predators, so they are often left alone to hunt for earthworms, insects, and snails amid the leaf litter. The cat snake (above), one of hundreds of kinds of snakes active mostly at night, moves through low vegetation to hunt frogs and lizards. Asian wild dogs, or dholes (below), prey on large game such as this sambar deer they killed at the edge of a river in Khao Yai National Park, Thailand. Once widespread across Asia, large numbers of these pack-hunting canids have been exterminated by locals, who perceive them as a threat to livestock. They are now reduced to remnant populations even in protected areas.

STRIX LEPTOGRAMMICA, DANUM VALLEY (LEFT)

HEXAMITOPTERA LAWINDA, DANUM VALLEY (ABOVE)

CORYMBORKIS VERATRIFOLIA, DANUM VALLEY (RIGHT)

Wide eyes blazing in the light of my camera flash, a brown wood owl poises on a forest perch. Excellent night vision helps owls fly through the dark forest, but, like tarsiers, owls also rely on their highly sensitive hearing to detect and capture a variety of prey: small rodents, lizards, frogs, even large insects. Well-camouflaged moths (top) survive the daylight hours by blending in with a background such as dead leaves or bark. By night they use their sense of smell—detectors built into their antennae—to locate mates and food. One evening as I entered the forest, I smelled a heady perfume coming from flowers opening to attract small moths (right). Like many night-blooming plants, this orchid has pale flowers that are easy to spot in low light. Pollinators home in on the flowers' scent from a distance and then use their vision to make the final approach.

MEGOPHRYS NASUTA, GUNUNG PALUNG (LEFT)

VIVERRA TANGALUNGA, GUNUNG PALUNG (ABOVE)

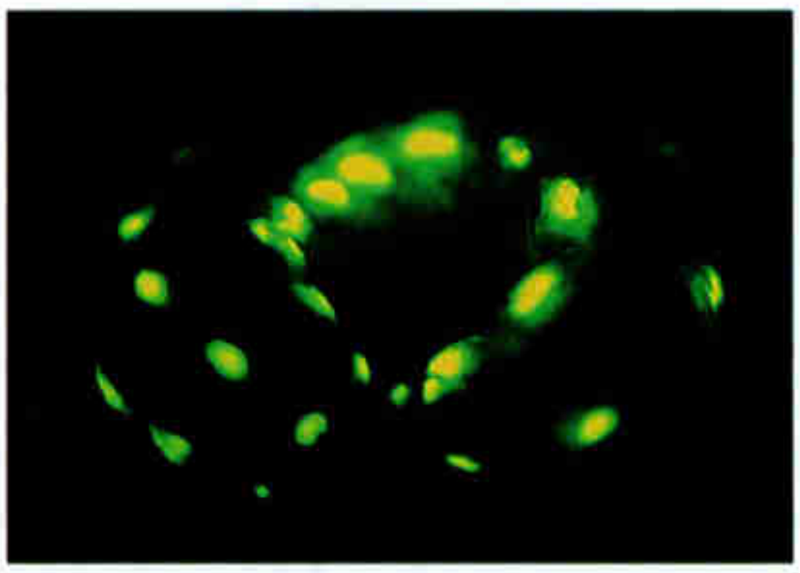
THERAPHOSIDAE, DANUM VALLEY (RIGHT)

No matter how closely you approach a Bornean horned frog (left), it won't budge. It acts as if its camouflage makes it invisible, and it very nearly does. Finding one is extremely difficult. In this case the reflection of its eyes in my headlamp beam gave it away. With a mouth as wide as half its body length, the horned frog simply waits for prey to pass by, and a large spider like this leggy tarantula emerging from its webbed retreat (above) would make a fine meal. The Malay civet (top) actively forages for anything edible. A bait of fish lured it to this site in Gunung Palung National Park, Indonesia, where it tripped my remote-controlled camera. Unfortunately Gunung Palung, like many parks in Indonesia, is now being devastated by illegal logging, and there seems to be little political means or will to stop it.

RHINOCOCHLIS NASUTA, GUNUNG PALUNG (LEFT)

PITTA GRANATINA, DANUM VALLEY (TOP RIGHT)

DIPLOCLADON SP., GUNUNG PALUNG (BOTTOM RIGHT)



As long as these forests remain intact, every night walk can reveal new marvels. A snail exploring a leaf performs a nimble pirouette at the tip (left). Perched on a twig where it can detect a predator's approach, a garnet pitta sleeps through the night (top right). The pitta, like many other diurnal birds, adds insurance while sleeping by fluffing up so much that an attacking snake might get only a mouthful of feathers. On a moonless, overcast night I turn off my headlamp and stand among the towering trees of Borneo's lowland forest. At first it seems as black as the deepest cave, but as my eyes adjust, I see that the forest has some light of its own. Patches of luminescent fungi are visible, and a bright point of light nearby turns out to be a strange beetle larva called a starworm crawling among fallen leaves (bottom right). Why does the starworm produce its steady glow? Could it be seeking mates? Luring prey? Alerting predators that it is inedible? For now it remains one of the many mysteries of the rain forest at night. □

MORE ON OUR WEBSITE

Watch the rain forest in action at night and hear its sounds. You'll also find more photographs and a list of related websites at **nationalgeographic.com/ngm/0110.**

BY PETER HESSLER

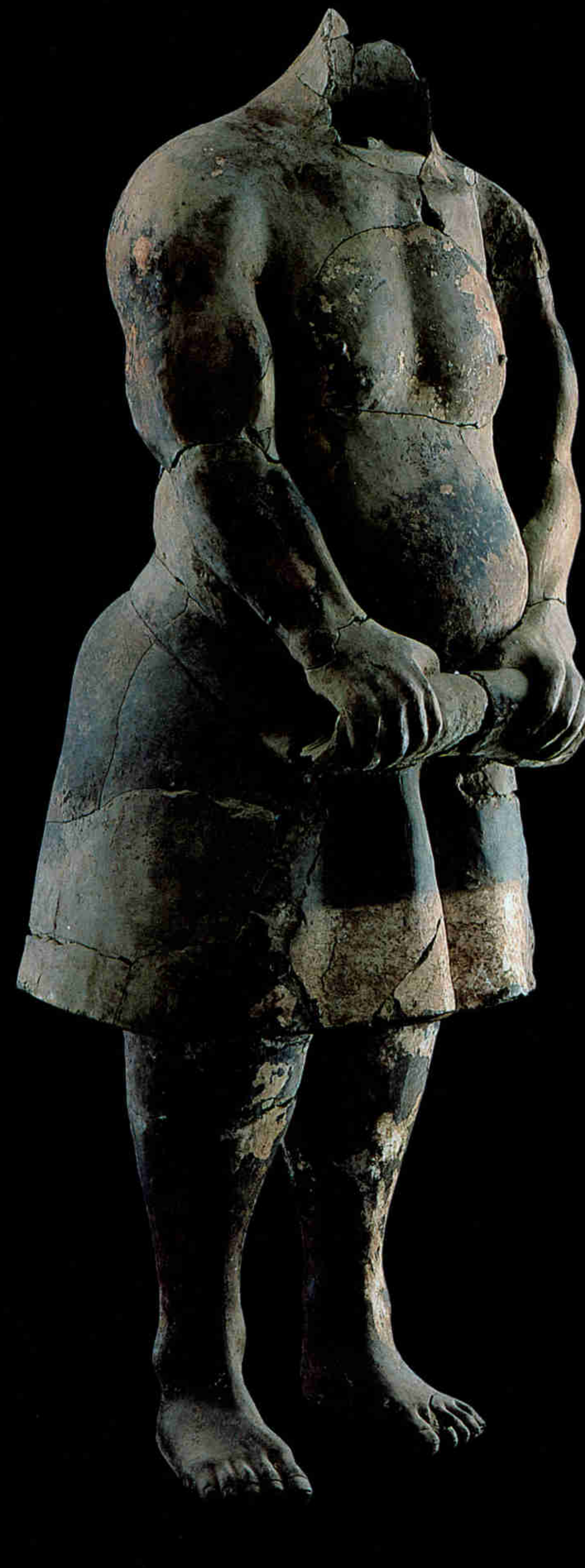
PHOTOGRAPHS BY
O. LOUIS MAZZATENTA

Colored pigments still enhance the faces of terra-cotta soldiers, who seem as lifelike as they were 2,200 years ago when buried to accompany China's first emperor, Qin Shi Huang Di, in the afterlife. Restoration is under way on an astonishing array of statuary and artifacts from his tomb complex and that of later ruler Han Jing Di.

RISING

TREASURES

TO LIFE
OF ANCIENT CHINA



SURPRISING REALISM

Artful blend of fat and muscle lends an authentic appearance to a portly man, perhaps an entertainer created to amuse Qin Shi Huang Di's spirit. Shown in two views, he may have held a pole used by an acrobat. Among others in the subterranean troupe—China's earliest life-size statues with realistic bodies—one clasps his wrist as if reciting a story (opposite, top). Another may have held a weight. A third extends a finger as if spinning a plate. Some scholars speculate that realism in statuary came through contact with tribes who may have been influenced by Greek art.

They make an odd couple, the archaeologist and the statue. Duan Qingbo stands in the restoration workshop of the Terra-cotta Warriors and Horses Museum, looking up at a statue he helped excavate in 1999. The terra-cotta figure is more than 2,200 years old, its life-size, naked upper body is powerfully muscled, and it has no head. Duan is 36 years old, his build is slight, and he has a face like an open book—quick-moving eyes and an easy smile. He laughs a lot. He is never far from a Stone Forest cigarette. Dwarfed by the massive figure at his side, he grins and says, "He's like Mike Tyson."

The statue absorbs the cultural non sequitur without comment. Silence and mystery compose his aura—nobody knows exactly what this statue represents, what the object is that he presses against his potbelly. The few known facts about the figure are little more than clues: It is the earliest example ever found in China of life-size statuary that shows the human form, apart from the face, in realistic detail, and it is part of a startling collection of new discoveries recently unearthed near the tomb mound of Qin Shi Huang Di, the first emperor to unify China under one dynasty, the Qin. In a burial complex previously best known for its regimented terra-cotta army, the potbellied statue is remarkably out of step—a mostly unclothed, nonmilitary figure whose head has been destroyed.

But like any good archaeologist, Duan isn't intimidated by uncertainties. Rather than guess at riddles, he simply points at what he sees—the bulge of a triceps, the subtle ripple of a latissimus dorsi—and the mystery fades away into awe. "Look at those muscles and bones," he says softly. "Most people have thought Chinese sculptors at that time didn't portray the human body as it really is."

For the past week I've been in Xian, hoping to gain a sense of the early stages of China's imperial history. This part of today's Shaanxi Province was where the first two imperial dynasties made their capitals, taking advantage of the natural defenses of the Huang (Yellow) River to the east and the Qin Ling Mountains to the south. The Qin ruled here from 221 to 207 B.C., and their collapse was followed by the rise of the Western Han dynasty, which ruled from 206 B.C. to A.D. 9.

Today these dynasties are being explored by excavations of two imperial tomb complexes, those of Qin Shi Huang Di and Han Jing Di, the fourth emperor of the Western Han, who ruled from 157 to 141 B.C. Because they saw the afterlife as a continuation of life on Earth, archaeology here is like dusting off a window to the past—a vision of what mattered to these rulers and their cultures.

Qin Shi Huang Di and Han Jing Di make another odd couple: a radical reformer, usually labeled a tyrant, whose dynasty collapsed only four years after his death, and a cautious ruler who relied in part on Taoist discretion to help solidify the power of a clan that reigned for more than four centuries. (After the Western Han collapsed, the same family reestablished the dynasty at a new capital and ruled as the Eastern Han from A.D. 25 to 220.)

Despite these two emperors' contrasts, they are nowadays linked by archaeology because no other imperial tomb complexes in the Xian region have been so extensively excavated. And their reigns span what may have been the most formative period in Chinese history, when a collection of warring kingdoms united into a single country with a strong imperial tradition. The Qin introduced this revolutionary concept of empire, and then the Han imbued it with a sense of tradition and order, setting the tone for more than 2,000 years of imperial rule.

Qin Shi Huang Di's achievement of a unified China has come to be represented by the more

than 1,500 terra-cotta warriors and horses excavated since 1974, when a group of peasants stumbled upon a pit of statues while digging a well. Designed to accompany Qin Shi Huang Di in the afterlife, the regimented figures reflect the ruler's military strength. But the massive army, estimated to be a total of 8,000 pieces, occupies only a fraction of the largely unexcavated tomb complex, which extends over 22 square miles and is said to have required a labor force of 700,000 to build.

One afternoon I climb to the top of the 250-foot-high tumulus above the emperor's burial site. From the summit, low dusty hills roll northward toward the horizon; to the south, a green carpet of pomegranate trees leads to the foothills of the Li Mountains, whose blue-gray peaks are sharply shadowed by the setting sun. It's a beautiful scene—but I find myself thinking more about the unknown treasures that are buried beneath my feet. And I think about the path I took around the back of the tomb mound, where I stepped over shards of 2,200-year-old ceramic tiles that lie half-buried in the dust. There's so much history here that it literally rises out of the ground.

Recently archaeologists have been doing some additional prodding. Although officials say they won't open the tomb mound itself until they are satisfied that preservation techniques are up to the challenge, they have permitted extensive soil testing that has left the earth around the tomb pockmarked with tiny holes. Since 1998 the authorities have also granted permission for two small experimental excavations of pits 650 feet southeast of the mound. One of these digs uncovered 12 nonmilitary statues that had been smashed by vandals in the distant past.

Although all but one of the heads was damaged beyond repair, archaeologists have been able to reconstruct five statues, including the potbellied strongman. The statues might represent *baixiyong*—performers who entertained the court with acrobatics, singing, dancing, feats of strength, and sleight of hand. Similar statues of smaller size have been found in Han tombs, but never before have any been dated to the Qin. To experts these discoveries are at once exciting and sobering: a

QIN SHI HUANG DI

Plumbing for treasures on Qin Shi Huang Di's burial grounds, a worker takes a core sample. Some probes go down as far as 90 feet. Any layer of disturbed soil indicates a promising spot for excavation. The opening of the emperor's tomb, inside the earth-covered 25-story-high pyramid in the background, awaits improvements in preservation techniques.

ART BY DOUG STERN

New finds flanking Qin Shi Huang Di's tomb offer snapshots of the lives of his subjects, thousands of whom worked on his burial site, which took 36 years to build and furnish.

ART BY HONGNIAN ZHANG

glimpse of something entirely unexpected but also a reminder of how little is actually known about the burial goods of Qin Shi Huang Di.

"We've realized there might be more varied figures in other pits," says Zhang Yinglan, vice-director of the museum's archaeological team. "These figures are concerned only with everyday life, while the others all have military aspects. The military ones are very stiff and formal, but these are so different."

Many of the newly unearthed figures are in motion. One appears to be in the act of lifting, another might be spinning something on his finger, and the potbellied statue may be using the object in his hands to grip a pole upon which an acrobat could perform. These figures suggest a lighter side of court life under Qin Shi Huang Di, but, most important, they represent a major artistic breakthrough in a culture whose traditional art never emphasized the anatomy of the human body.

"You wouldn't believe that they were Chinese if you didn't know where they'd come from," says Wang Tao, a lecturer in the department of art and archaeology at the University of London's School of Oriental and African Studies. He compares the statues' style to that of the ancient Greeks—and indeed these figures may reflect Qin cultural exchanges with non-Chinese peoples. Before unifying China, the state of Qin was on the western fringes of what would eventually become the empire, and Qin Shi Huang Di's ancestors were in contact with a number of foreign tribes whose art may have been influenced by interactions with ancient Greece.

The terra-cotta statues are also a powerful example of how archaeology can refine and sharpen views of history. The traditional view of Chinese history has stressed Qin Shi Huang Di's "unifications": standardization of the writing system, currency, weights and measures, and axle widths (to facilitate transportation). The emperor is also known for building the first version of the Great Wall. The dynasty name, pronounced "cheen," is probably the

PREPARING FOR THE HEREAFTER

Greatly fearing death, Qin Shi Huang Di began work on his grave site upon taking power in 246 B.C. Chief Minister Li Si (left, at upper right) directs the placement of statuary. First stone armor found in China, a ceremonial helmet and vest were made of limestone plates with bronze wire. Emperor from 221 to 210 B.C., Qin Shi Huang Di standardized currency, the writing system, and weights and measures. But his relentless expansion was called canshi, *or "eating away in silkworm fashion," and his achievements relied on forced labor and an exploited peasantry.*

source of the English word for China. But despite their enormous impact, Qin Shi Huang Di and his state have been written off as not much better than barbarians.

"Qin has the same customs as the Rong and Di," complained an official of the neighboring state of Wei in 266 B.C., comparing the rising Qin state to barbarian tribes. "It has the heart of a tiger or a wolf. . . . It knows nothing about traditional mores, proper relationships, and virtuous conduct."

Over the centuries most Chinese historians have agreed, but the new discoveries suggest that the growing confidence of the Qin state may have allowed for the creative freedom to

REGAL VESSEL

With a dentist's drill and a magnifier, a worker teases out caked mud from intricate figures of plants and animals decorating a bronze cauldron thought to have held food offerings at the emperor's memorial hall. At 467 pounds, it is the largest pot yet unearthed at a Qin-era site.

experiment with artistic concepts like realistic depiction of the human body. "Here we have a representation and an artistic language that's unique to this period," says Wang Tao. "And it was lost in later periods of Chinese art. It's like a rediscovery of something completely new."

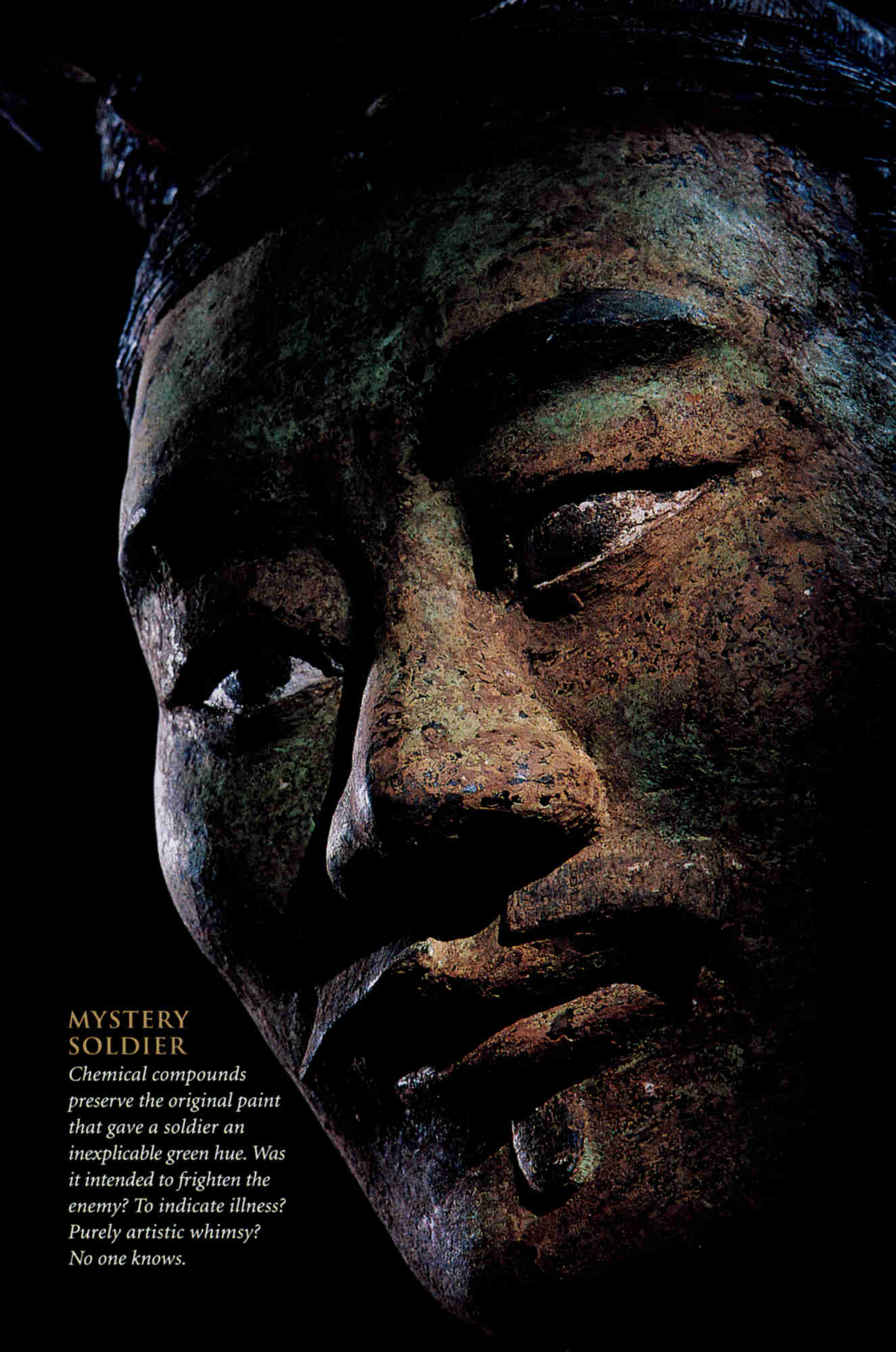
ONE MORNING I VISIT Pits 1 and 2 of the Terra-cotta Warriors and Horses Museum with Liu Zhancheng, an archaeologist who has spent upwards of 20 years working at the site. Looking out over the first pit, I'm struck by the scene's regularity: the neat rows of more than a thousand regimented statues, their ranks divided by the carefully excavated compressed dirt walls of the pits.

But Liu knows that this order is something of a mirage. Most of the statues in this pit were damaged centuries ago by vandalism, fires, and moisture, leaving thousands of terra-cotta shards that had to be pieced together. Some damage was too great for even the most patient reconstruction. All the army's warriors were originally colored, but the Qin painting process involved applying pigments to a layer of lacquer that deteriorates in humid conditions. Most of the figures in Pit 1 lost their color long before archaeologists started work. And for the statues whose pigments survived the centuries, excavation proved to be too great a stress.

"Once we excavated a figure with the colors intact," remembers the soft-spoken Liu. "When we took it outside, though, the paint layer started curling up and peeling off right before our eyes. Within ten minutes it was gone. As an archaeologist I felt horrible about it, but there was nothing I could do."

Knowing that some sections of the site might contain more undamaged figures, museum officials slowed the pace of excavation, partly to focus on researching chemical compounds that would stabilize the lacquer layer. In 1988 the Shaanxi Province Cultural Relics Bureau signed an agreement to work with the Bavarian State Conservation Office, based in Munich, Germany. Chemists and art preservationists from both countries tested more than 30 possible compounds before arriving at a solution known as PEG, sometimes used to prevent excavated wood artifacts from drying out too quickly. A version of the compound proved effective on terra-cotta. In 1999 the museum performed its first on-site test, choosing a far corner of Pit 2 that hadn't been damaged by vandals. Working at a painstaking pace with fine tools—"like dentists," says Liu—the team of archaeologists and chemists spent more than a year uncovering six figures.

Suddenly Qin Shi Huang Di's world appeared in Technicolor. The colors—reds and greens and blues and purples—vary from soldier to soldier, and experts have yet to find a connection between color and rank or function. There are unexpected touches like contrasting shirt cuffs. And then there's the strangest discovery of all: one figure whose face is painted green. He may have been



MYSTERY SOLDIER

Chemical compounds preserve the original paint that gave a soldier an inexplicable green hue. Was it intended to frighten the enemy? To indicate illness? Purely artistic whimsy? No one knows.

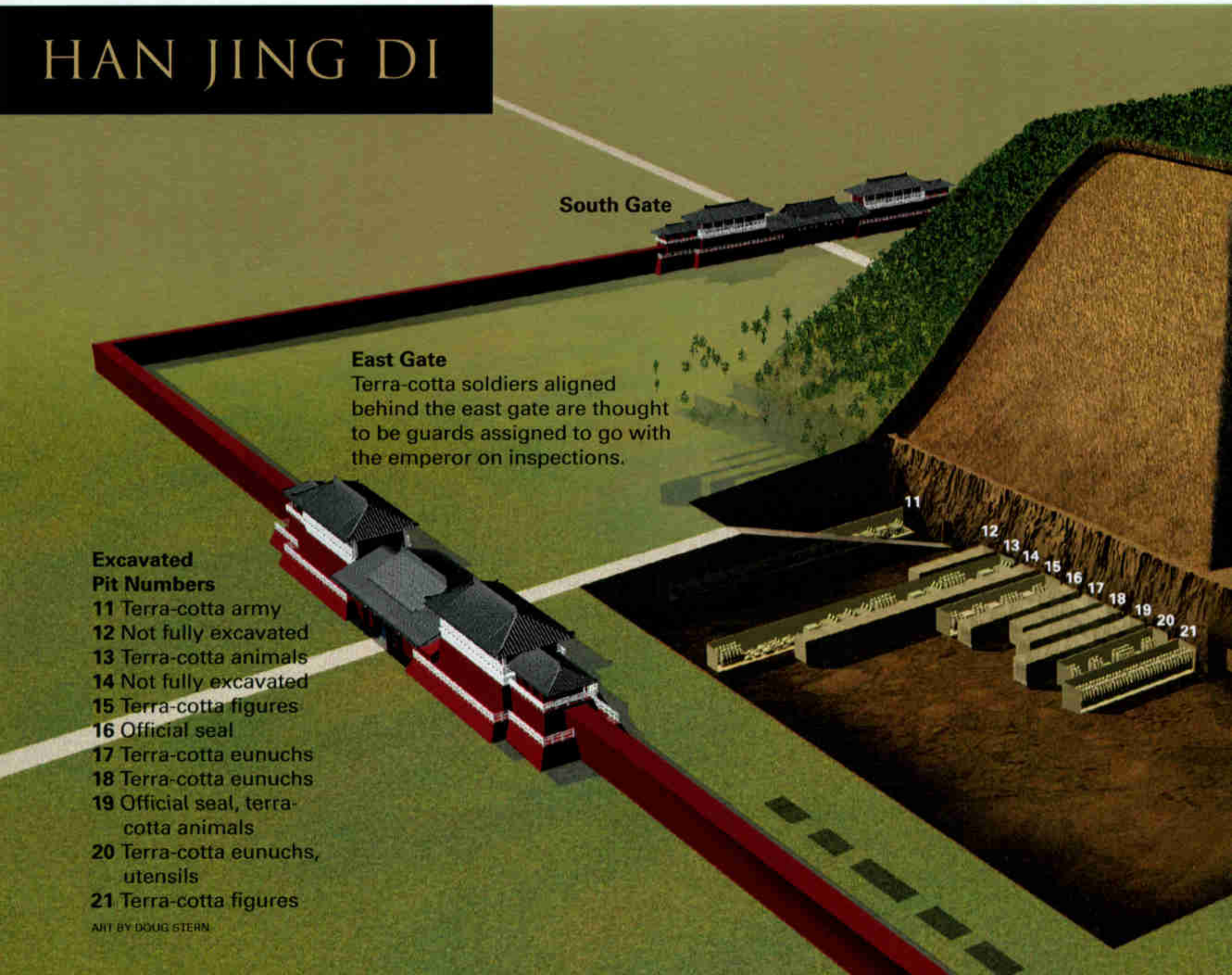
intended to frighten the enemy, or possibly the touch was purely artistic.

"You might ask why there aren't other quirks in the soldiers—for example, why do they all pose the same way?" asks Liu, standing in the test excavation site. The pudgy, round-faced archaeologist looks vaguely out of place in the midst of the six fierce warriors, who are kneeling at attention, crossbows at their sides, prepared to rise and fire at the command that still hasn't sounded after 2,200 years. "They can't be disorganized, because they're soldiers," says Liu. "But the colors might have provided some individuality and artistic flair that the form could not. This suggests that when these figures were made, the question of whether they were beautiful or not was even more important than whether they were standard."

But like all the archaeologists I've spoken with, Liu is quick to emphasize that this is only a preliminary theory that must wait until further excavations are done. It's like working on a puzzle where adding new pieces makes the picture larger rather than more complete.

This sense of an expanding mystery is especially vivid at the two experimental pits. In addition to the performers, these digs have yielded a massive 467-pound bronze cauldron, the largest ever found at a Qin-period site, and a pit of ceremonial armor made of carved pieces of limestone. The stone-armor pit is strewn with thousands of limestone plates that are charred by a fire nobody can explain. Tests show that the pit containing the cauldron and the entertainers covers about 960 square yards, but officials granted permission for less than 9 percent of it to be opened by the 1999 test excavation. A full-scale excavation will wait until authorities feel that the time is right.

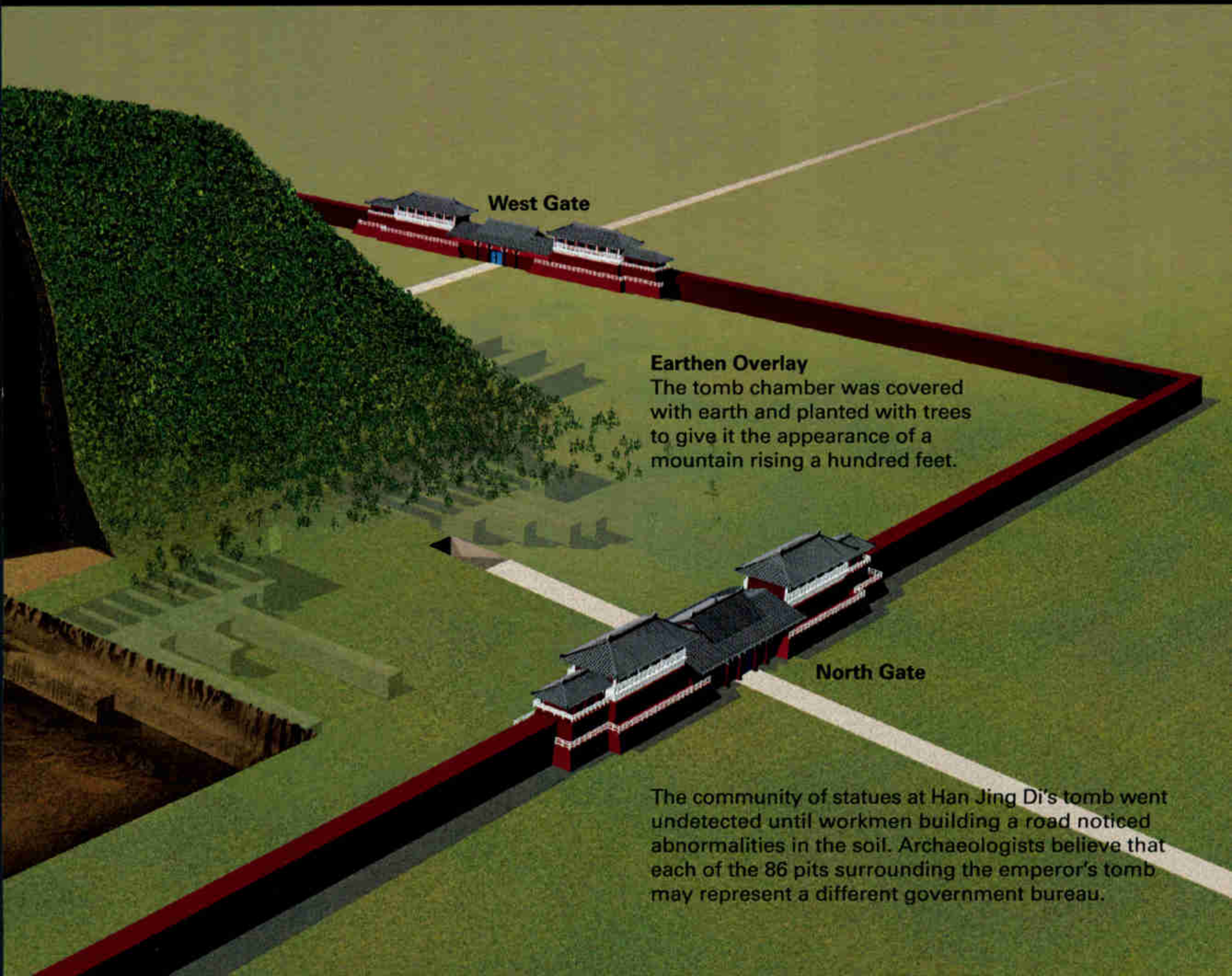
Meanwhile the land has already shifted back from archaeological time to the ageless rhythms of the countryside. Local peasants have planted pomegranate trees on the site, and the fruit is coming into season 20 feet above the unknown treasures. The archaeologists have already moved on. They have opened a third experimental pit, in which they found 12 life-size statues. It's another breakthrough:



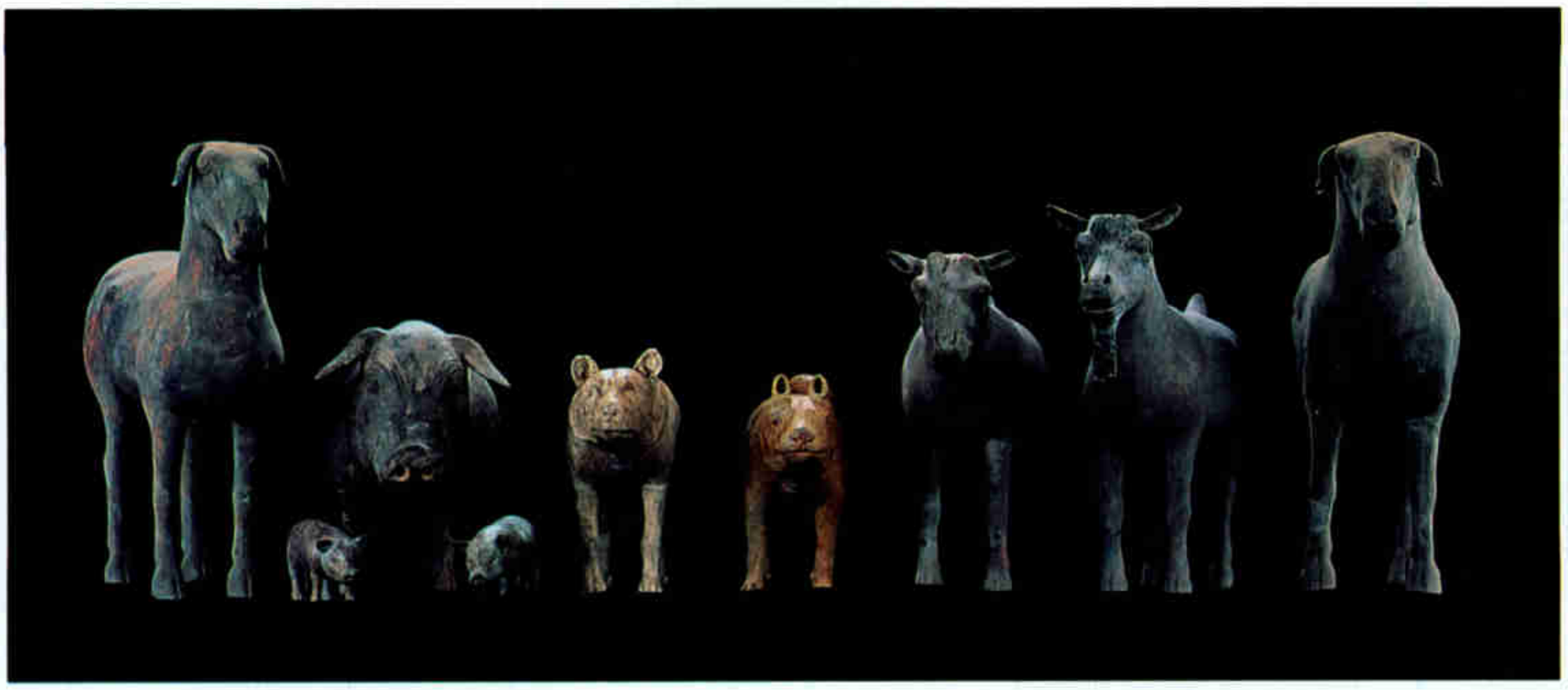
ART BY DOUG STERN

STILL COMMANDING HOMAGE

Squads of workers weed newly planted grass on the sweeping burial grounds of Han Jing Di, whose tomb lies within the mound beyond. Cross-hatched tablets found at the south gate appear to be board games similar to chess. Han Jing Di ruled from 157 to 141 B.C. as the fourth emperor of the Han dynasty. He is one of 11 Han emperors buried near Xian, capital of Shaanxi Province. Qin Shi Huang Di's oppressive style led to a peasant revolt; Han Jing Di is said to have ruled with a gentler approach, marked by reduced taxation, under which the empire flourished.



The community of statues at Han Jing Di's tomb went undetected until workmen building a road noticed abnormalities in the soil. Archaeologists believe that each of the 86 pits surrounding the emperor's tomb may represent a different government bureau.



AFTERWORLD FARMYARD

Multitudes of domestic animals (opposite) including sheep, pigs, dogs, and goats await a butcher who has yet to come. A Chinese emperor's afterlife was believed to be as eventful and elaborate as life before death, and his grave site was furnished to meet his every need.

The nonmilitary figures wear hats and long robes; their hands are crossed at their waists. Perhaps they are government officials. And so the puzzle expands, piece by piece emerging from the red Shaanxi soil.

TWENTY-FIVE MILES WEST of the Terra-cotta Warriors Museum, I find a harvest of a different sort: carefully arranged rows of terra-cotta pigs, sheep, goats, and dogs excavated from the tomb complex of Han Jing Di. This site is one of Xian's newest tourist attractions, open to visitors since the end of 1999. It too is an excavation in progress—as I can see from the animal pit, where some of the sheep are still half-uncovered, wading in dust up to their fattened flanks.

"In the first level we've found more than 400 terra-cotta dogs, 200 sheep, and we're still not sure how many pigs," says archaeologist Ma Yongying. "They were put in the tomb to feed the emperor."

Perhaps this is to be expected from a dynasty whose founder, Liu Bang, rose to power with the assistance of military supporters who had been dog butchers. Despite its humble beginnings, the Han has always been seen as one of China's most successful dynasties, ruling through a combination of pragmatism and precise organization. Indeed these characteristics are reflected in the relics that are emerging from the tomb complex, which is known as Han Yangling. Since 1990, when a construction project accidentally came across a pit of terra-cotta soldiers, archaeologists have excavated a large collection of burial items that say more about everyday life than war: animals, chariots, spades, saws, adzes, chisels, plowshares, miniature granaries, ladles, stoves, steamers, and measuring devices. Considering that Han Jing Di came to power only 53 years after the burial of Qin Shi Huang Di and his terra-cotta army, these preliminary discoveries seem to indicate a change in philosophy—and, quite possibly, a reaction against the earlier dynasty.

"Qin Shi Huang was a tyrant. Whatever he wanted, he got," says Liu Qingzhu, director of the Chinese Institute of Archaeology in Beijing. "His tomb didn't have to follow a system, so you might have certain figures over here and different ones somewhere else. But what we've found at Han Yangling is very orderly—each pit contains certain objects arranged in a certain way; it's all very regular."

Over the course of a 17-year reign that ended in 141 B.C., Han Jing Di governed by the most unpretentious of slogans: "*Wu wei er zhi,*" a Taoist saying that means "Do nothing in order to govern," or, essentially, rule as unobtrusively as possible. Historians claim that whereas peasants paid half their crops in taxes under Qin Shi Huang Di, Han Jing Di levied only 3 percent. Mandatory corvée was dramatically reduced. There were no major building projects on *(Continued on page 66)*

IMPERIAL ESCORT

A worker's delicate touch cleans dirt from a terra-cotta horseman assigned to ride a wooden mount in the emperor's otherworldly entourage. Han Jing Di's statues were approximately one-third life-size, reflecting a tenure that was somewhat less given to self-glorification and oppression than Qin Shi Huang Di's.

FROZEN GRACE

Embodiment of femininity takes a pronounced willowy form in a statue whose scarlet coloration is being restored. Though corroded, a chromium mirror (right, in background) still casts a reflection (above). A similar mirror's reverse side bears intricate designs in bronze.

the scale of the Great Wall. And the empire, according to historical texts, flourished.

Archaeology may very well reinforce this view, providing an unprecedented look at political organization under the Han. While Han Jing Di's tomb mound, like the burial site of Qin Shi Huang Di, won't be opened anytime soon, experts have been excavating a series of 11 of the 86 satellite pits that surround the tumulus.

"We think that every pit might represent a specific government bureau," says Wang Baoping, who has worked at Han Yangling since 1990. "In two pits we've even found official chops that give the names of specific departments." One of these chops, or seals, identifies the office in charge of the imperial kitchen, which may explain why there are so many animals in this part of the tomb complex. Other relics include hundreds of terra-cotta figures of soldiers, eunuchs, and women. Unlike the statues of Qin Shi Huang Di, which were

VIGILANCE

A two-foot-high soldier's iron sword and leather armor outlasted his wooden arms. Han Jing Di's figures bear expressions more benign than Qin Shi Huang Di's life-size statues.

mostly formed by hand, the figures at Han Yangling were made entirely with molds—although craftsmen retouched the faces to give them individual expressions. The biggest difference, though, is simply size: Most of the Han Yangling figures are roughly one-third life-size.

"We think of the early Han dynasty as a period when the emperors were thrifty," says Ma Yongying. "The objects here are much smaller than the Qin, probably in order to save materials and manpower. And some of the gold relics we've found are merely plated with gold."

But while the Han may have seemed thrifty compared with the Qin, the discoveries at Han Yangling reflect a culture that still valued extravagant burials. Archaeologists have already uncovered more than 40,000 objects from the satellite pits, another group of pits to the south, and a cluster of nobles' tombs. There's still the untouched emperor's burial mound, as well as two separate tombs for Han Jing Di's empress and favorite concubine. The entire tomb complex is expected to yield between 300,000 and 500,000 relics.

"There are 31 more pits surrounding the empress's mound," says Li Gang, the youngest archaeologist at Han Yangling. "And we're testing the concubine's tomb, where we expect to find more pits. Whenever we're finished with all of that, there are still more than 5,000 other Han tombs scattered across this area. That should give you some sense of how much work we still have to do."

He gives a tired grin, a 28-year-old going on 100. And suddenly I have a sense of how many people like this young man have been involved in the constantly expanding puzzle of Xian's imperial past. I imagine those who built these two imperial tombs centuries ago—artisans, planners, laborers—and then I think about all the present-day archaeologists, chemists, historians, and art experts who are uncovering and making sense of the new finds. Somewhere in the midst of all this effort are the touchstones of a civilization: the brilliant creativity that first inspired the concept of a unified empire and the steady pragmatism that kept it going for more than 2,000 years.

But this is a lot to think about, and once again I focus on the finest detail—the bulge of a terra-cotta muscle, the curve of a sculpted bone. I remember Duan Qingbo standing awestruck next to the potbellied statue, and I recall a sunny afternoon when the two of us sat on top of Qin Shi Huang Di's tomb mound. We were facing south, gazing toward the Li Mountains. Directly below, a group of peasants were planting corn. Next to the peasants, a cluster of archaeologists conducted soil tests. Duan could identify with both—he was the son of peasants, and he had spent more than a decade excavating around the Xian region. A Stone Forest cigarette hung from his lip. I asked him if he'd like to open the tomb on which we sat.

"The truth is, even if we do excavate it, we might not completely understand what we find," he said, laughing. "We need to move slowly with our excavations. After all, we have children, grandchildren. Let them open it." □

BARED BUT UNBOWED

Slender statues of a woman, a man, and a eunuch who guarded concubines once sported silk clothing and wooden arms that rotated, all disintegrated long ago. Through the painstaking work of archaeologists, royal servants who have slept for 2,000 years are slowly being awakened.

MORE ON OUR WEBSITE

Find more scenes from the everyday afterlife of China's early emperors at **national geographic.com/ngm/0110.**

ONCE AND

CALIFORNIA'S VOLCANIC NORTH

Born of colossal collisions and far from dead, California's volcanoes have inspired fiery legends, New Age religions, and, from time to time, sheer terror. Cinder Cone in Lassen Volcanic National Park is just one vivid reminder.

BY PRIIT J. VESILIND
NATIONAL GEOGRAPHIC SENIOR WRITER

PHOTOGRAPHS BY JIM RICHARDSON

FUTURE FURY

YOU'RE A HELPLESS PASSENGER ON A PLATE OF CONTINENTAL CRUST THAT GLIDES ACROSS THE

planet's seething interior. If you live in North America, chances are you're on a plate that's inching westward. If you live in northern California, there's another hulking crust, the Gorda plate, coming at you beneath the sea.

Where they meet, like sumo wrestlers grappling, the Gorda dives and grinds beneath the continent. Stone melts and turns to magma, and the magma churns to the surface and tosses up an arc of volcanoes, shaping the Cascade Range that reaches from northern California into Canada.

The Cascades seemed to simmer underfoot when I joined Michael Clynne, a geologist with the U.S. Geological Survey (USGS), at Lassen Volcanic National Park. We had to tiptoe across a field of steaming fumaroles and stinking, burping mud pots. A boardwalk built for sightseers had just collapsed from landslides.

"This is very dynamic land," said Clynne, a sturdy man with a rowdy brown beard. "The plumbing changes all the time, and there's a danger of falling through to a pocket of hot water or gas or hot sticky mud that you can't get off soon enough to prevent burning."

Indeed, the nearby thermal area known as Bumpass Hell was named for Kendall Vanhook Bumpass, an explorer and mountain man who fell into a boiling mud pot in 1865 and had to have his leg amputated.

In the global picture the Cascades form only one span of the volcanic Ring of Fire that surrounds the Pacific Ocean, where other oceanic and continental plates collide. Swept up in this geologic creep are scraps of the Earth's crust called terranes. Terranes extend from moving plates, so they often crash into continents rather than subduct beneath them. Geologists now say that California and much of the North American west coast were pieced together from dozens of terranes that rode in on drifting plates.

Science and fantasy mingle readily where science is already fantastic. In 1931 an American writer named Wishar Cervé postulated that one piece of migrating crust was a remnant of Lemuria, a mythical continent that had been sinking into the Pacific. Rising water had forced the beings who inhabited Lemuria to flee to high ground. When the mountains of Lemuria finally collided with a westward-moving North America, they sutured themselves to the continent and became the Cascades.

Today the faithful claim that Lemurians are a superior people who still live in a gold-lined city built inside Mount Shasta, the most mesmerizing of the Cascade volcanoes, and that Lemurians used to emerge, dressed in flowing white robes, to trade gold nuggets for supplies at local stores. Pilgrims still arrive at the town of Mt. Shasta each year, hoping to encounter Lemurians. A few say they do.

"A lot of people think of Mount Shasta as a powerful spiritual vortex," said Ashalyn, who advertises her services in town as a spiritualist. "People want to connect with that energy."

Ashalyn, a blond flower child grown cheerfully middle-aged, drove me through the manzanita and sagebrush north of Mount Shasta to Pluto Cave, a series of underground tubes left by lava flows about 200,000 years ago.

"Sacred places are what customers want to see," she whispered as we entered a chamber whose ceiling stretched 30 feet above us.

FEEL THE BURN **Narrowly avoiding a steam blast known to reach 165 miles an hour, geochemist Cathy Janik prepares to sample the hottest fumarole in Devils Kitchen, a geothermal area five miles southeast of Lassen Peak. On this day the vent hit a record 254°F.**

SECRETS IN STONE **Cinder Cone's Fantastic Lava Beds looked so new to early researchers they misdated them by 200 years. Yet the beds pale in geologic significance to the eruption 300,000 years ago that toppled an ancestral Mount Shasta and strewed its remnants 30 miles into the Shasta Valley (above right).**

Carrying flashlights, we picked our way across a boulder-strewn floor and sat in the velvet darkness. Water dripped hypnotically from the ceiling. We waited. "I'm hearing the cave say, 'I welcome you into my belly,'" said Ashalyn.

What else is he saying?

"He says that the Earth is constantly in motion, just like our bodies. Tension is building upon its surface, like a stretched rubber band. The geologies of the Mother are shifting and looking for a place to come to rest."

Yes, yes. That describes the cooling of the planet in soothing family terms. The poor thing's just suffering a few eons of tectonic discomfort before it settles down. "Let's go a little deeper," said Ashalyn and urged me to extend energy down the "grounding cord" of my spine to the center of the Earth. I tried, although I was skeptical about finding cosmic answers down below.

Mount Shasta is one of three major volcanoes, each a different type, that dominate northern California. It's a stratovolcano built high and handsome by layers of liquid eruptions. Lassen Peak is a plug dome whose crater is blocked by lava that was once as viscous as peanut butter. The third, Medicine Lake, is a low-lying shield volcano, shaped like a Roman warrior's shield, whose black rubble forms the edge of wetlands called the Klamath Basin.

The northern California volcanic region is splendid with scientific facts. The cycles of volcanism are laid out clear as museum specimens: craters caped in snow, dark paws of lava, hills of glossy obsidian, and cinder cones that look as if poured yesterday. But most of the people who have lived here, from Native Americans to New Age spiritualists, have sought other explanations for what they

struggled to understand. Nearly every feature of this landscape of unworldly beauty and primeval power has an alternative answer, a legend, or at least a good story.

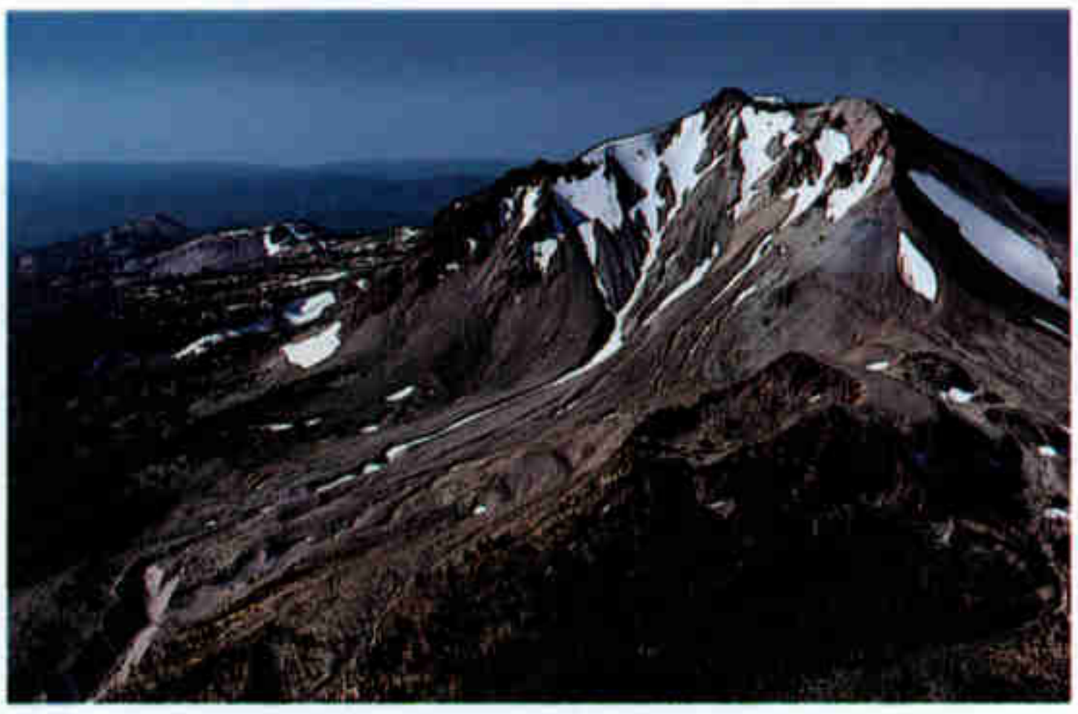
THE FIRST SNOW had fallen the week before I arrived. Cold had bleached the ferns that clustered around trout streams, but aspen leaves billowed sunny yellow in the valleys. This is not the classic basin-and-range California; it's more a part of the Pacific Northwest.

Most of the summer folks had retreated from Chester, a lumber-mill town in a valley near Lassen Peak, southernmost of the Cascade volcanoes. A sign on the Pine Shack Frosty stand offered free ice cream to anyone ordering during a volcanic eruption.

"We're not really in danger here," said Jerry Young, the cheerfully gruff, retired sheriff sergeant of Plumas County, as I sat with him and his cronies one morning at Danny's Kopper Kettle Cafe. "But since Mount St. Helens erupted in 1980, it's always in the back of our minds. Lassen blew on the other side in 1915, but the only effect the mountain has had on us is flooding. We get heavy snows up here."

Before the California gold rush of the mid-1800s tens of thousands of Native Americans, in four tribes, lived around Lassen, subsisting on fish, game, roots, and acorn meal. In Yana oral history Mount Lassen was Waganupa, the center of the world, whose snows melted and created canyons, caves, and ridges. Some heroes and gods are said to have transformed themselves into the ancestors of men, bears, and other living things. But some local Indians believe that two of the supernatural beings still live, like Lemurians, deep inside the mountain.

Mexico still owned California when Peter Lassen, a Danish immigrant, arrived in the early 1840s. The peak bears his name, and in 1916 President Woodrow Wilson corralled nearly all the wonders of the area for Lassen



❶ AVALANCHE HUMMOCKS
Shasta has been quiet for 200 years, but its potential firepower is evident in Shasta Valley's hummocky terrain, shaped by an avalanche from an earlier eruption that nearly leveled the volcano.

Park, now more than 150 square miles. That was barely a year after the peak erupted.

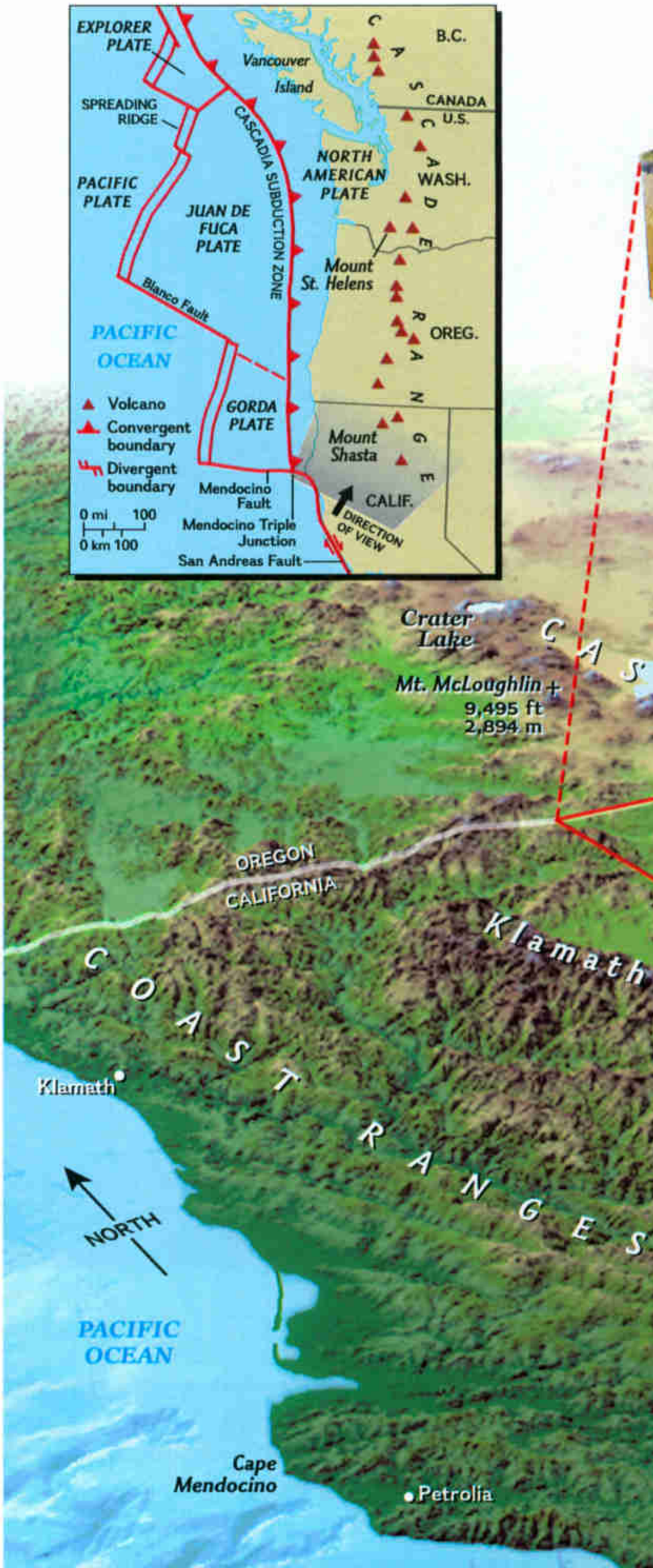
On May 30, 1914, Lassen awoke with steam explosions that eventually blasted out a crater that is a thousand feet wide. When the eruption climaxed nearly a year later, rock fragments and pumice spiraled 30,000 feet high. A pyroclastic flow—an avalanche of hot ash, pumice, rock, snow, and gas—thundered down Lost Creek, northwest of the summit, turning into a mudflow, flooding the valley, and destroying houses near the town of Old Station.

Michael Clynne and I drove the 30-mile-long park road just before it closed for the snow season. "There have been three major eruptions at Lassen in the past 1,100 years," said Clynne. "The winter of 1915 was an El Niño year, with 30 feet of snow on the slopes. An avalanche took out trees on both sides; you can find car-size rocks that it carried down."

Some of the features look as fresh as yesterday. Rising 700 feet from its base, a cone of cinder sits symmetrical as sand in an hourglass on the park's northeast edge. It formed when lava shattered in midair, settling in fragments. Dunes of ash, tinted yellow and red from minerals, drift from the cone, a Martian landscape colonized by a few stunted pines.

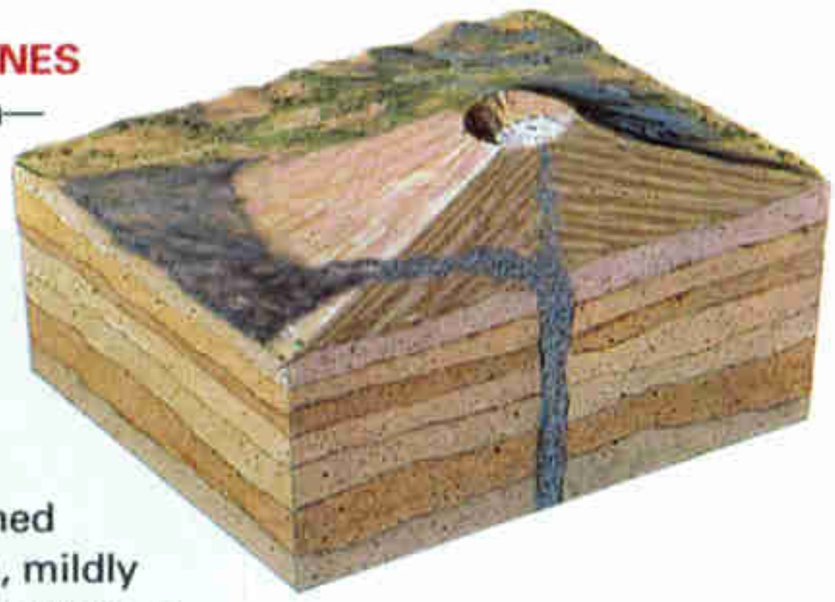
It's a much abused country. Forest fires, fortified by too much brush and tinder, often sear the land on top; fire and brimstone rise like demons from below.

NEAR THE TOP of Mount Shasta, 70 miles northwest of Lassen, a thermal field vents sulfurous fumes. Thousands of climbers scale the peak in summer months. "The stuff has a pH of approximately 2," said Michael Zanger, a mountaineer from the town of Mt. Shasta. "It



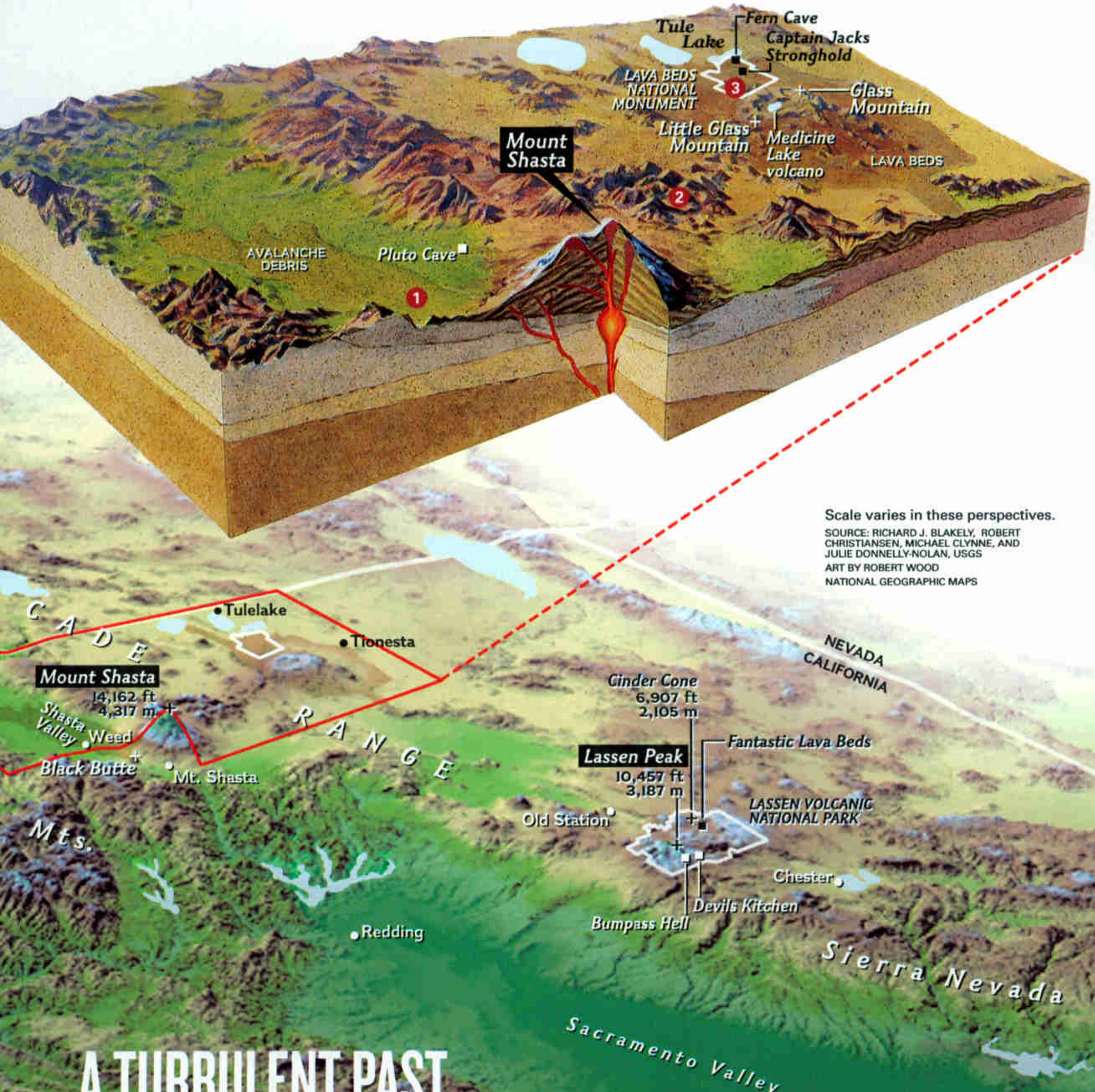
❷ CINDER CONES

Made of tephra—lava blown into the air and solidified—cinder cones are usually small, steep-sided structures formed during a single, mildly explosive event. Heavier lava normally flows from the base.



❸ LAVA TUBES

Like a river moving beneath a layer of ice, 2200°F lava continues to flow as its surface cools, hardens, and insulates the flow beneath. When the hot lava pours out, a long lava tube often remains.



A TURBULENT PAST

Three tectonic plates collide off Cape Mendocino, stoking northern California's volcanic fires, particularly the grinding of the Gorda plate under North America. Lassen Peak (opposite, top) was the latest to erupt, in 1915. Like Mount St. Helens, its larger sister farther north, Lassen's biggest blast flattened forests for miles. Slowly recovering, the devastated area is just one legacy of a restless land.

UNFORGETTABLE **"White and flashing like a pyramid of silver" is how poet Joaquin Miller saw Mount Shasta. Built by eruption after eruption, the peak inspires such awe it has become a mecca for New Age pilgrims. New beliefs meld with old at a celebration of the Maya New Year (above right).**

would eat the chrome right off your camera."

A Shasta tale explains that the ill smell comes from the time when a group of yellow jackets volunteered to take the people's meat from a great slaughter to the ice of the mountaintop to preserve it. But the load was heavy, and the yellow jackets were lazy. They ditched the meat below the altitude of constant freezing, where it rotted and still remains.

Mount Shasta is a majestic, 14,162-foot-high double peak that floats ethereally alone above the high arid landscape. Like Mount Fuji or Kilimanjaro, it's known as one of the world's most sacred mountains. It's a forceful presence. I found myself peering up at odd times, muttering, "Yes, yes, I know you're there."

A school of art in California venerated the mountain in the late 1800s, rendering Mount Shasta in many media and moods. Joaquin Miller, utopian and perhaps first among the popular writers who were touched by the mountain, called it "lonely as God, and white as a winter moon."

For some local Indians, Mount Shasta was the wigwam of the Creator, and its smoking caldera his cook fire. None would approach its high reaches without purification ceremonies. Disrespectful behavior on the mountain, the people of the Pit River tribe believe, can be punished by the *je suchin*, the black imps.

Mount Shasta owes its grandeur to a series of outbursts. The last was in the late 1700s, but its violent potential always lurks. Michael Zanger, who leads ski and climbing expeditions, warned, "There are five billion cubic feet of snow on Shasta. An eruption could be an unimaginable catastrophe, with mudflows going down the Sacramento Valley and its cities."

The town of Mt. Shasta, at the base of the peak, abuts Interstate 5, which links California with the rest of the Northwest. The mountain makes its presence felt more than 50 miles south, in Redding. Black Butte, a dark dome, sidles right up to the interstate, and Route 97, near the town of Weed, swings around a lava flow that reaches like the paw of a black cat stretching.

Mount Shasta has been a magnet for spiritualists since the late 1800s, when a local teenager, Frederick Spencer Oliver, claimed that he was possessed by the spirit of Phylos the Thibetan while working on the mountain. Oliver's book, *A Dweller on Two Planets,* inspired a cult following. Since then the town has welcomed, often grudgingly, seekers of truth from New Age philosophers to Christian sects.

"There are stories of people who drive past here, their cars break down, and they can't leave. They *have* to live here," said Dawn Fazende. She's an enigmatically serene woman with soft bangs and five house cats who publishes a magazine for New Agers, people she calls the Woos.

Woos?

"Yeah. We all came here, looked at the mountain, and said, 'Woo-woo!'"

If Shasta pushes your heavenly buttons, Medicine Lake volcano, only a few dozen miles to the northeast, brings you down to Earth. It has no obvious peak because its outbursts have been too liquid; its lava spread out rather than piling up. Perhaps because it lacks height, it also lacks mystery, and the few people who live in the region are mostly meat-and-potatoes pragmatists who remain here despite, not because of, the landscape.

The region's geology is best seen at Lava Beds National Monument, but it's a land more suitable for trolls than people, a plateau of sagebrush badlands pocked with pit craters,

INTO THE MAW Ranger Kelly Fuhrmann stands beneath the skylight of one of some 400 lava-tube caves in Lava Beds National Monument. Formed when outer layers of a flow cool rapidly and solidify as the remaining lava drains out, such caves litter the area that was the last redoubt for Modoc Indians. Their war with the U.S. government ended in 1873.

SHARP AS GLASS **Contoured by snow, Little Glass Mountain oozed from Medicine Lake volcano 1,100 years ago like a 200-foot-high wall of taffy. Nearby Glass Mountain, rich in silica, cooled rapidly and formed obsidian (right), used to make scalpels that can be a hundred times sharper than steel.**

caves, gunmetal gray spatter cones, and dumps of grotesquely shaped lava that volcano-savvy Hawaiians named *'a'a*, perhaps for what happens when you walk barefoot on it.

"The Modoc lava beds have an uncanny look, that only an eager desire to learn their geology could overcome," wrote John Muir.

Even more bizarre and treacherous a landscape is Glass Mountain, a tumble of obsidian east of Medicine Lake's epicenter where migratory hunter-gatherers shaped ceremonial blades nearly a thousand years ago. The most striking obsidian is a licorice black rhyolite formed when lava cools quickly into glassy, rather than crystalline, rock.

The extended Klamath Basin was once a glacial lake sprawling over more than a thousand square miles. Now much of it has been drained in order to plant onions, potatoes, and other vegetables. A community of Mexicans who came as seasonal pickers lives year-round in the weathered Oregon-border town of Tulelake, the "horseradish capital of the world." The region harbors six national wildlife refuges swarming with coots, geese, and ducks and offers hunting for migratory waterfowl. A sign at my motel asks: "Please do not pick and clean birds in room."

"This is thunderhead and lightning country, big skies," said Julie Donnelly-Nolan, a USGS geologist. "There's nothing much you can do with the land. You can run a few cows on it, but it isn't usable farmland—just rock."

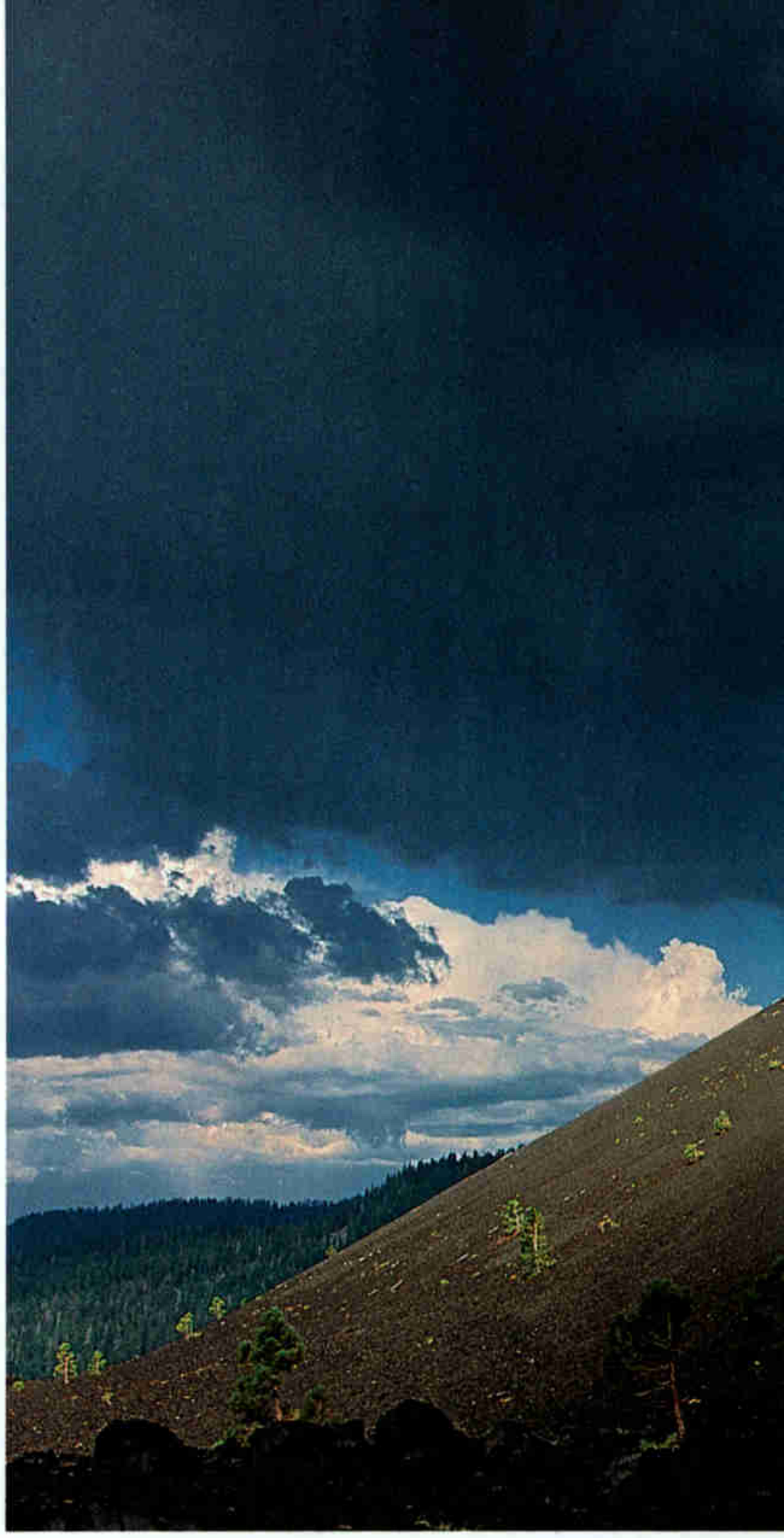
Donnelly-Nolan has determined that Medicine Lake began erupting about 500,000 years ago, "mostly as a field of domes. And then, about 300,000 years ago, the shield volcano began to form over the top."

As lava oozed down shallow depressions and

valleys, the outer shells of flows cooled more quickly than their insides, leaving hollow, wormlike lava tubes. More than 400 tube caves snake through the 73-square-mile monument alone. Some of their ceilings are 40 feet high and encrusted with delicate silicate formations and ice stalactites. For Indians as well as New Agers the tubes are the entranceways to the spirit life inside the mountains.

With an aptly named ranger, Jeff LaRock, I visited Fern Cave, which is still sacred to the Modoc, an Indian tribe that had lived on the Lost River by nearby Tule Lake. An emerald tuft of ferns, found nowhere else within 125 miles, survives in a microclimate just below the cave's entry shaft. LaRock, a rather dry and fastidious young man, surprised me by turning around three times before entering the cave, out of respect for the Modoc's beliefs.

"Modoc still use Fern Cave for rituals," he said. "They come here for reunions every summer, and some stay for days, drumming and meditating." Inside, the cave is decorated with early Indian art and steeped in at least a thousand years of human history.



IN THE MID-19TH CENTURY pressure from settlers drove the Modoc from their home, and the government obtusely transferred them to Oregon to share a reservation with the Klamath, their historic enemies. In 1872 a band of fed-up Modoc led by Kintpuash, also known as Captain Jack, drifted back and demanded their own reservation at Lost River. Raids and killings poisoned chances for a peaceful resolution, and full-scale war soon flared.

Captain Jack and his followers holed up near Tule Lake in a natural fortress of pit craters and convoluted lava caves known today as Captain Jacks Stronghold. For four months about 170 Indians, men and women, held out against a force that eventually numbered 600. In the end the Army hanged Captain Jack and three of his men. The remaining Modoc were exiled to Oklahoma.

California's north can be desolate. A prisoner of war camp for World War II German and Italian officers still sits beside a volcanic bluff near Tule Lake; only miles away is a former internment center for Japanese Americans. At a former logging town called Tionesta an enclave of 30 individualists soured on the government live between large timber company lands and federal holdings.

"Everybody's still living in the 1800s here," said Jim Addison, owner of Tionesta's Timber Mountain general store. "They all live the old style. They all believe in honor." Here people still talk about the great storm of 1992, when the snows were so heavy in the mountains that deer were forced to find refuge on highways and railroad

MORE ON OUR WEBSITE

Find more photographs, with the tech facts behind the frames, at **nationalgeographic.com/ngm/0110**.

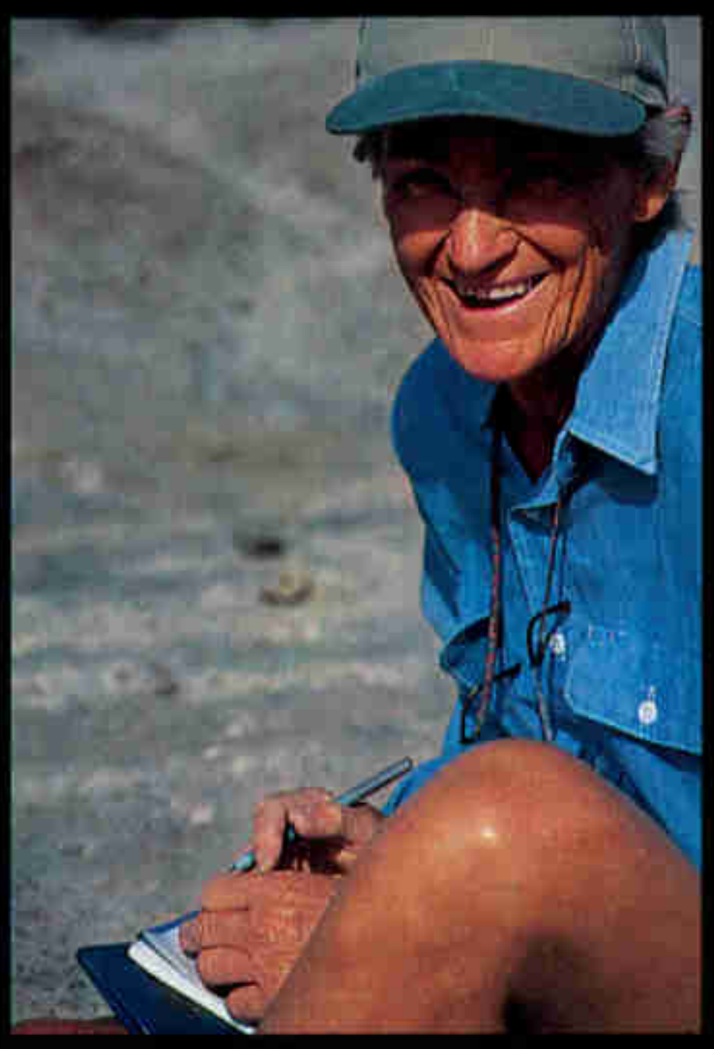
BUILDING BLOCKS **Trudging through loose ash, hikers climb the 700-foot-high flank of Cinder Cone. Big Cascade peaks may get the glory, but countless smaller volcanoes built the backbone of the range.**

tracks, the only open spaces. Trains and trucks just plowed through them, and according to local legend the stench of rotten flesh spoiled the springtime.

But in the humbling magnitude of geologic time, wars, suffering, and life itself have been mere flickers. Now geologists say that the Gorda plate has nearly disappeared. As it subducts beneath North America, it pulls up the arc of volcanism like a zipper.

As this ponderous movement winds down, it transfers its energy from the Gorda to the sliver of crustal California west of the San Andreas Fault, a terrane that's drifting north toward Alaska with its own Lemurians aboard. But the languorous waltz of the continents, the power of internal Earth, and the undeniable grace of the Creator will leave a rare beauty in far northern California. More than once while wandering around Mount Shasta or the parapets of Lassen, I would come upon a scene of startling clarity and color that I had seen before only in wistful dreams. I could understand how, as the Woos say, some people cannot bring themselves to leave. □

NATIONAL GEOGRAPHIC RESEARCH AND EXPLORATION



GRANTEE
Meave Leakey
Paleoanthropologist
Kenya, Africa
Quote: "One of these early hominids was ancestral to us, but we don't know which. It could well be something we haven't yet found."

Another Leakey rewrites another chapter in the African story

Meave Leakey holds the reassembled skull of *Kenyanthropus platyops* ("flat-faced Kenya man"), a new candidate for humankind's ancestor.

Meet Kenya Man

of humankind's dim beginnings.

LOUISE LEAKEY (INSET); ROBERT CAMPBELL © NATIONAL MUSEUMS OF KENYA

Ten years of searching the scrubby badlands west of Kenya's Lake Turkana had produced a trove of discoveries, but the grand prize—a hominid skull—still eluded them. With the 1999 field season almost over, Meave Leakey moved her team of fossil hunters to a new part of the ancient landscape. On the second day, after several hours of walking bent over, eyes searching the pebble-strewn ground, team member Justus Erus spotted a fossil poking out of the dirt. He said to himself, Could it be a monkey? Leakey knew at once it was a hominid, one of humankind's bipedal predecessors. She knelt down and began teasing bits of bone from the hard clay. Hours passed, and still she continued to excavate in the 110°F heat. It took several days to collect the fossil and transport it to a lab in Nairobi. A year and a half later, after the rock had been removed and all but the smallest, bread-crumb-size fragments fitted back together, the resulting skull shook the human family tree.

"It spoils the easy straight-line picture of the past," Leakey says. "We have to rethink some theories." Until the discovery of *Kenyanthropus platyops* there had been just one group of candidates for humankind's ancestor between four and three million years ago—members of the genus *Australopithecus*, most notably *A. afarensis*, made famous by the fossil skeleton called Lucy. But *K. platyops*, dated at 3.5 to 3.2 million years old, is different enough from *afarensis* to arguably be classed as a new genus. Yet like Lucy it possesses traits that suggest it could have given rise to *Homo*, the human line.

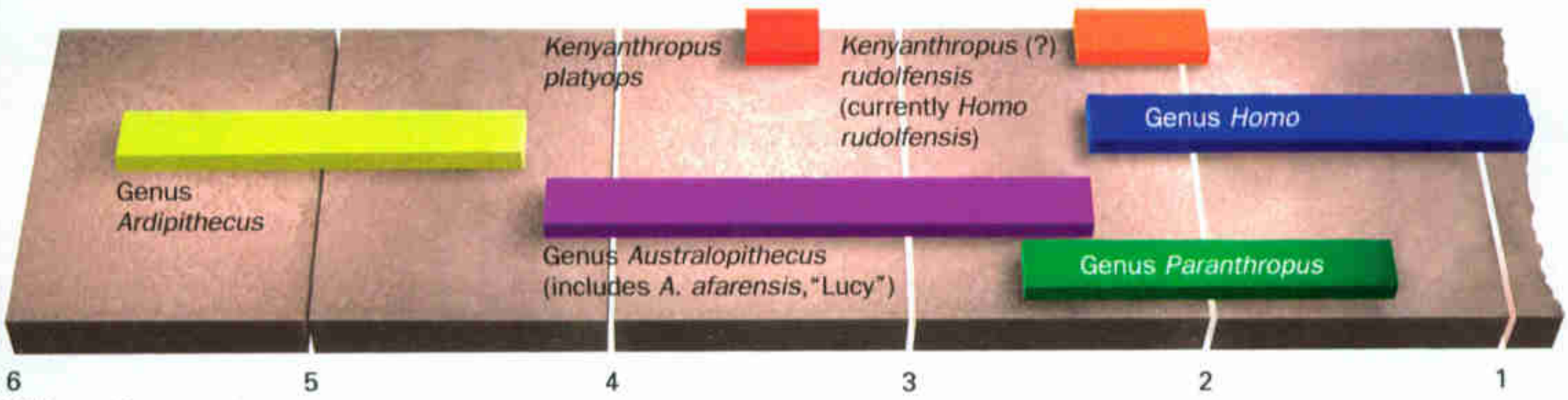
THE PROJECT

YEARS OF FIELD WORK: 33
LEAKEY LUCK?: "IT'S PERSEVERANCE."
CHILDHOOD HOBBY: DOING JIGSAW PUZZLES WITH THE PIECES TURNED UPSIDE DOWN
MOTIVATION: "YOU'RE ALWAYS EXPECTING TO FIND SOMETHING."
HEIR APPARENT: DAUGHTER LOUISE

For decades Leakey worked happily in near anonymity beside her better known husband, Richard, studying fossil monkeys and carnivores while he dealt with more glamorous hominids. "Richard was the person in the

New Entry on a Rough Chart of Human Origins

"I don't like drawing family trees," says Leakey. "We simply don't have the evidence." Yet she feels confident placing *K. platyops* on a separate branch from *A. afarensis*, the famed Lucy. Beyond that, scientists aren't sure. *"Afarensis* and *platyops* had ancestors," says Donald Johanson, Lucy's discoverer. "But did they have descendants?"



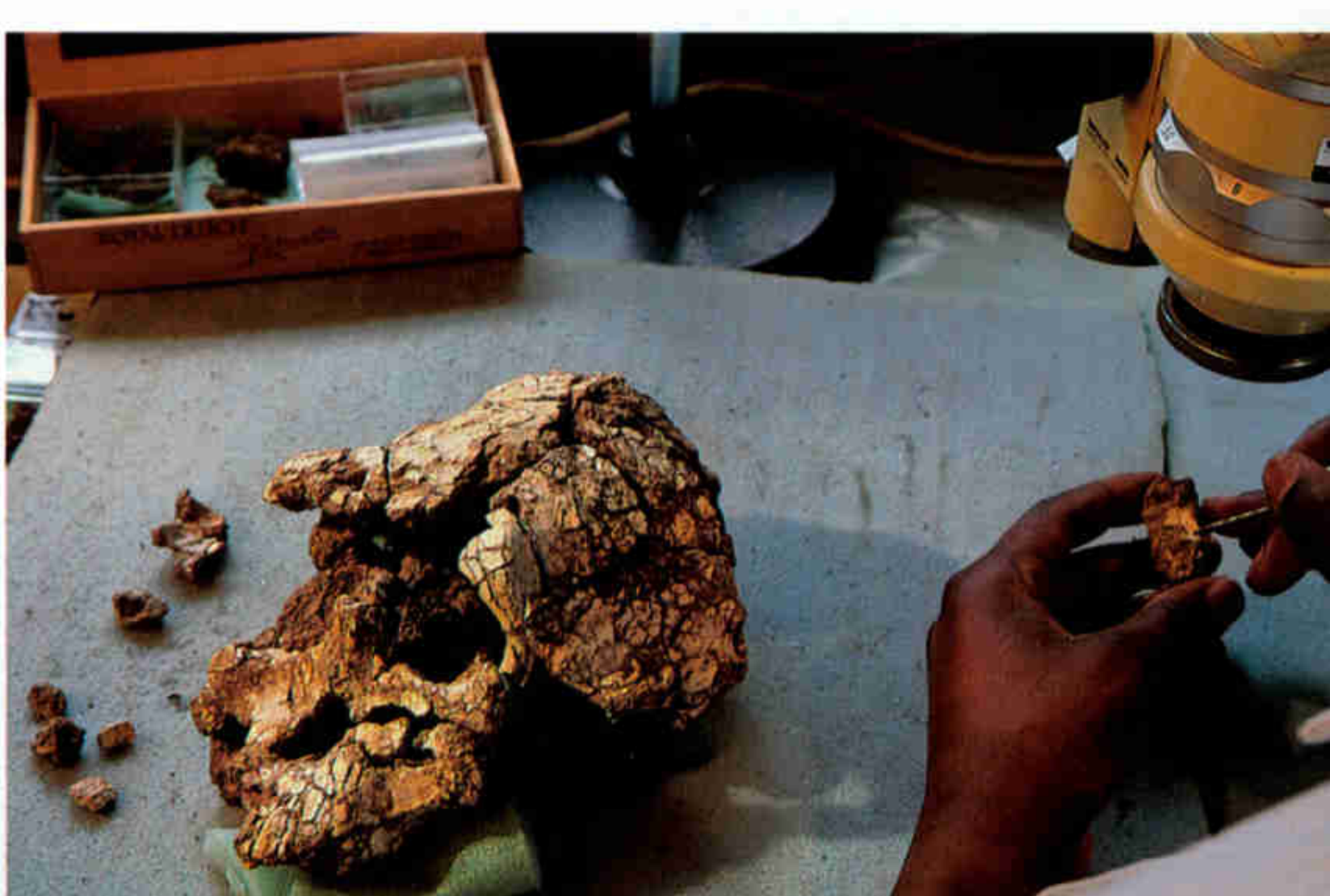
JOHN R. ANDERSON, JR., NGM ART

limelight," she says. "I liked it that way." Yet in 1989 she took over Richard's fieldwork. "The fame is a bit of a nuisance," she says. "But it's important the team knows the world is looking on." Asked what sets her apart from others in the field, she says only, "Having a good site and an excellent team."

"Meave is overly modest," says Donald Johanson, Lucy's discoverer, who calls Leakey "the embodiment of paleoanthropology." He and other colleagues attribute Leakey's success to hard work, patience, thoroughness, and determination. "She just goes back and goes back and goes back," says Frank Brown, a geologist on her team. "I asked her why

PATRICK NDURU GATHOGO (ABOVE); KENNETH GARRETT © NATIONAL MUSEUMS OF KENYA

Leakey uses a dental pick to coax *K. platyops* skull fragments out of surrounding clay (above). "You have to work incredibly slowly," she says. At the National Museums of Kenya, Christopher Kiarie (below) moistens the fossil with acetone so he can tell bone from stone, then uses a microscope and an engraving tool to remove the rock grain by grain. At first Leakey and her team didn't know whether *platyops* belonged in Lucy's genus or represented a separate evolutionary branch. "In spite of trying very hard to find similarities," Leakey says, "the more we looked at it the more differences we found."



On hands and knees, Leakey's team members scour the ground, collecting every fossil in their paths at a rich site near where Leakey unearthed *K. platyops.* Fragments that had broken off the skull were sifted out of the dirt, then sorted on a tray in camp (below right).

"It's like a jigsaw puzzle in three dimensions and with no end to it."

—MEAVE LEAKEY

she kept looking in the same place, and she said, 'Fossil hominids have been collected here, and I can't believe all of them have been found.' "

Hominid remains make up less than one-thousandth of the fossil record found around Lake Turkana. In between such rare finds Leakey, initially trained as a zoologist, focuses her enthusiasm on animals that lived with humankind's ancestors. "When fossil hunters find something—even if it's not hominid—she's always excited," says Patrick Gathogo, a Kenyan graduate student who got his start volunteering for Leakey. "She's interested in everything because it relates to the whole story."

K. platyops shows that humans evolved through the same process as other animals, Leakey says. A novel adaptation (walking on two legs) produced a bloom of species—*A. afarensis, K. platyops,* and others Leakey expects will eventually be found.

"It's important to know that we're the sole remaining species," she says. "We're one little twig left on the past's complicated tree." □

—By Karen E. Lange, Editorial Staff

MORE ON OUR WEBSITE

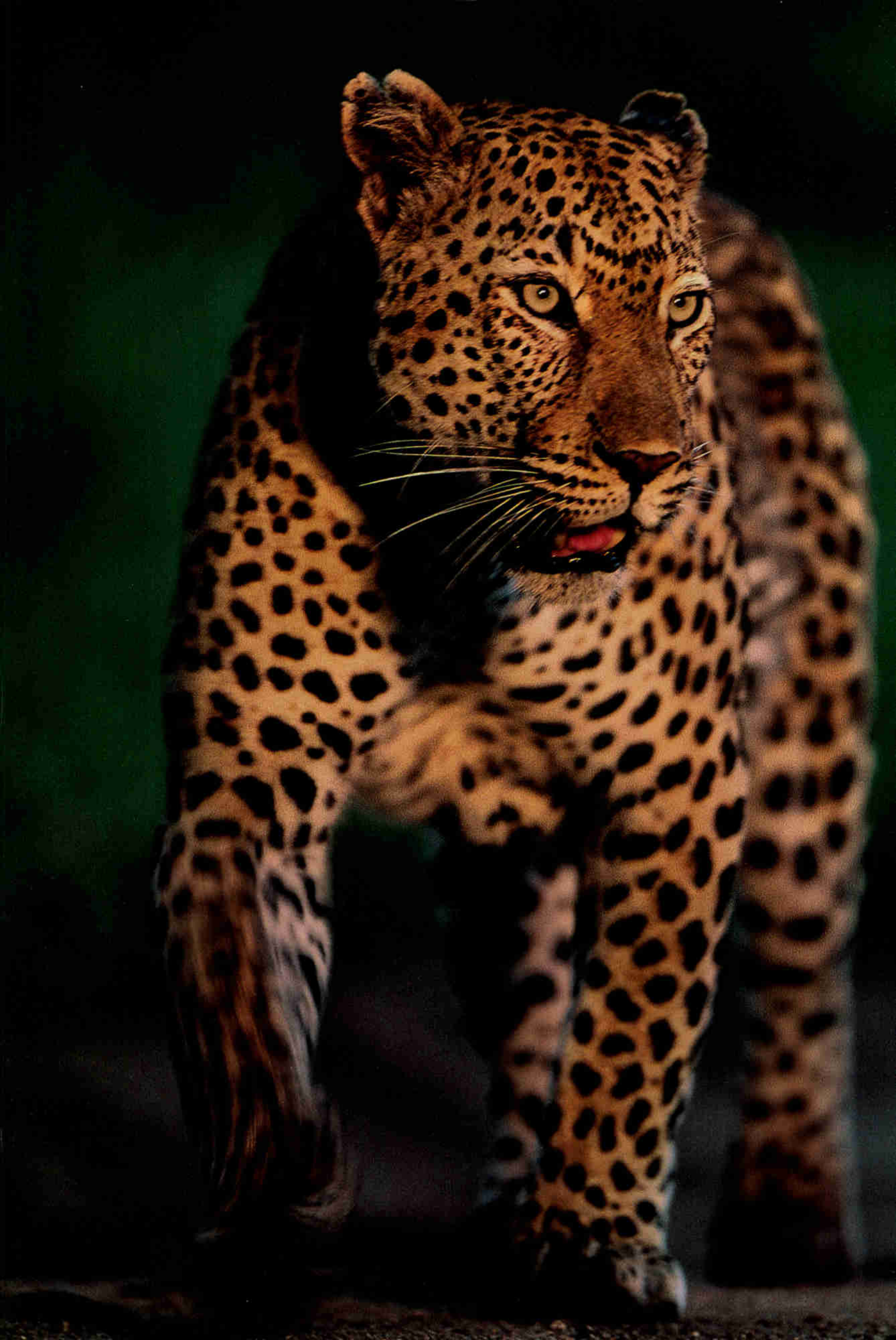
Post a question for Meave Leakey and watch for her weekly replies at **nationalgeographic.com/ngm/0110.**

BOTH BY MEAVE LEAKEY

Splendor in the grass, a male leopard acknowledges my continuing presence in his territory in a private South African nature reserve, then goes back to his heat-of-the-day doze. Though he barely bats an eye, I know that he is aware of my every move.

TJOLO

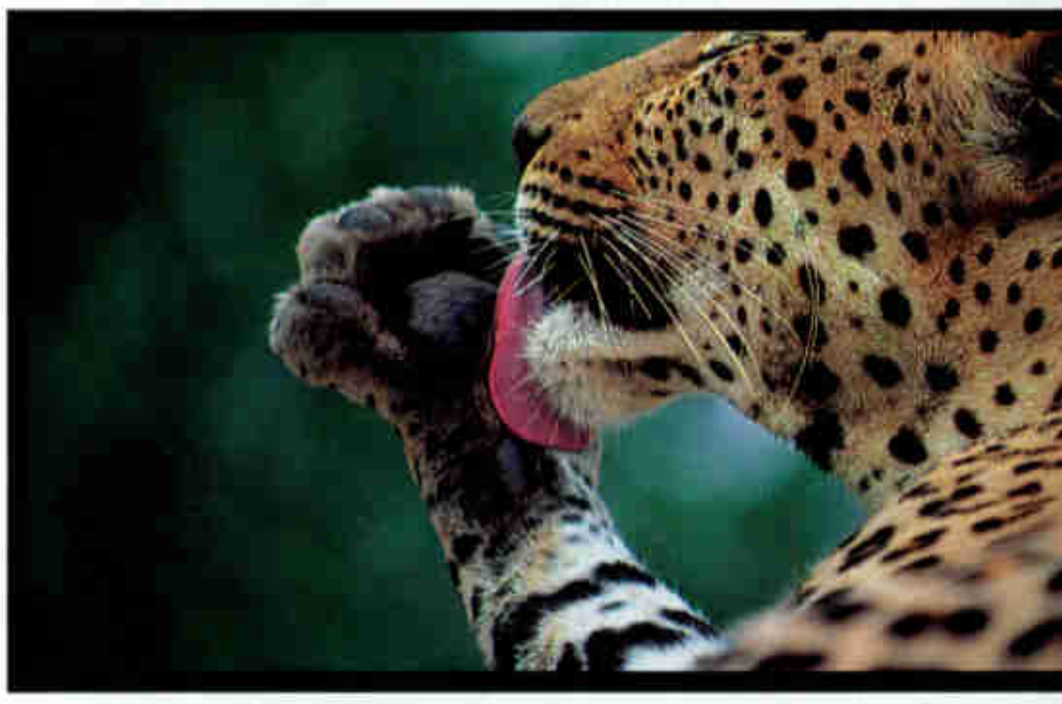
TRACKING THE LEOPARD

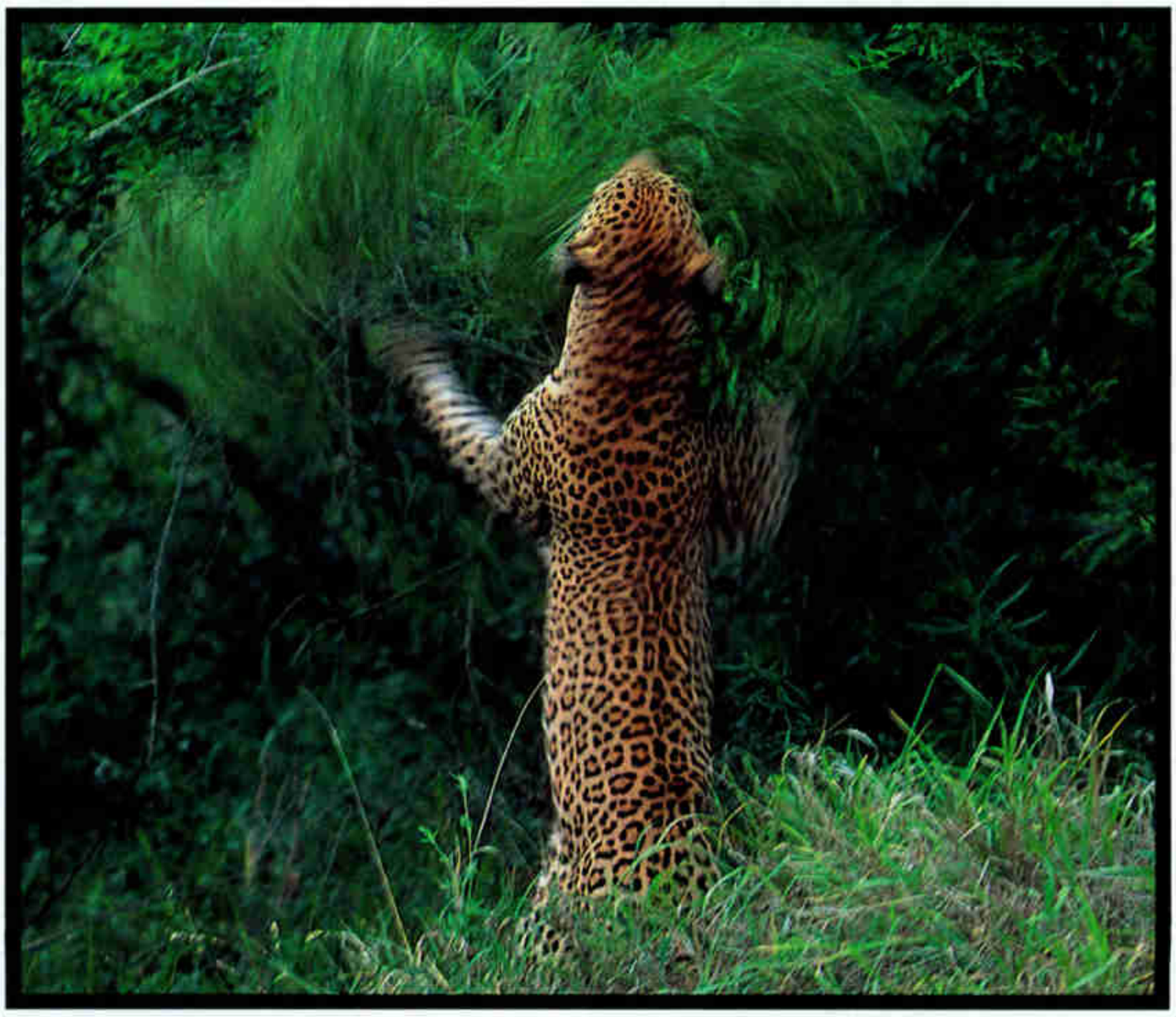


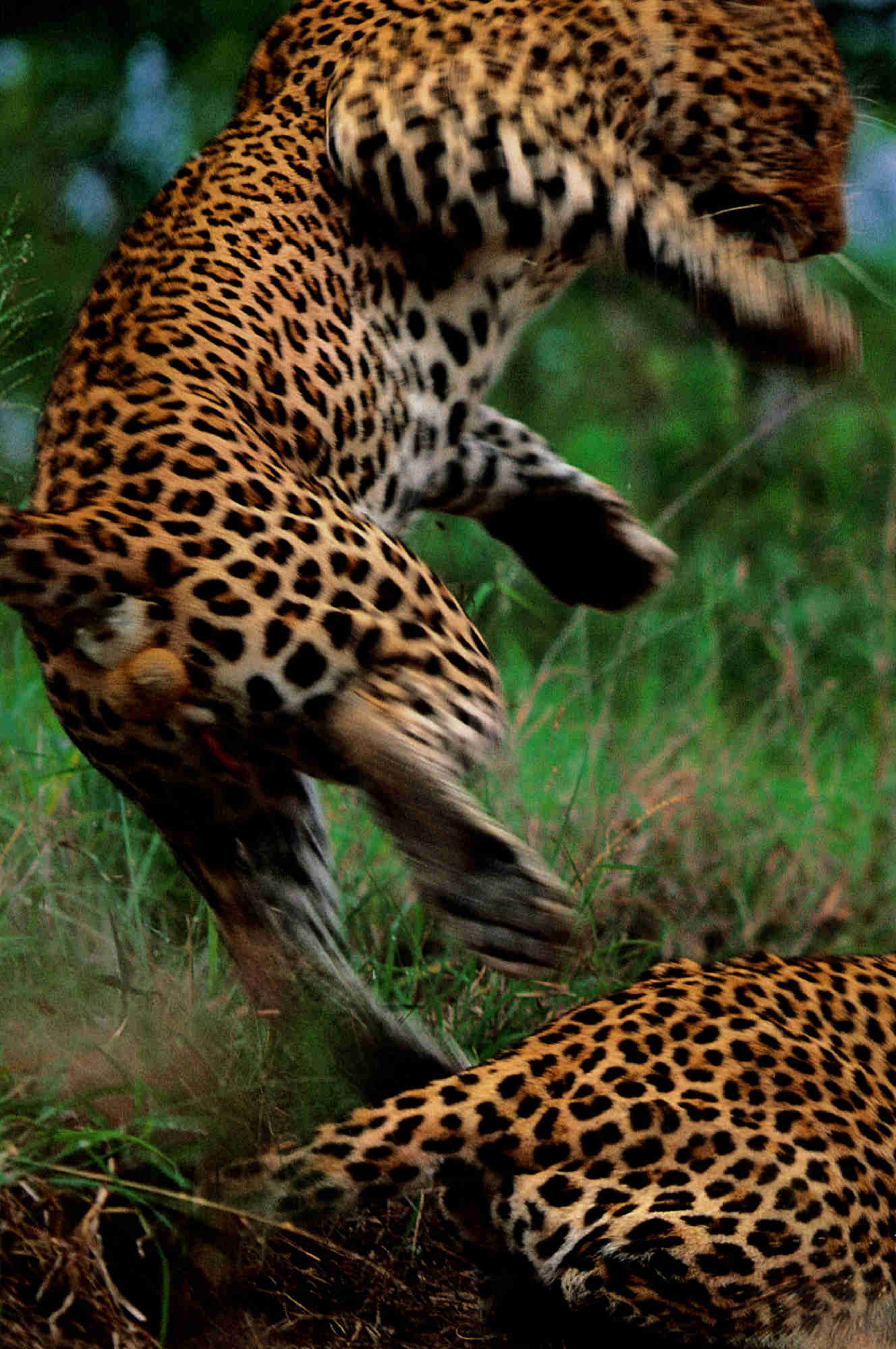
ARTICLE AND PHOTOGRAPHS BY KIM WOLHUTER

Of the leopard, naturalist Maitland Edey wrote, "He is an animal of darkness, and even in the dark he travels alone." Yet over the course of 19 months one male leopard in South Africa's Mala Mala Game Reserve allowed me to become his companion. I named him Tjololo, a melding of words from the Swazi and Shangaan languages, which means "the one that stands alone."

It can be a struggle to follow *Panthera pardus* in the bush, but years ago a veterinarian at neighboring Kruger National Park had implanted a tracking device in Tjololo to monitor his recovery after he was injured by a warthog. As a former park ranger, I was granted exclusive use of the implant's frequency, allowing me to track Tjololo's progress and gain his trust. Eventually I could get close enough to hear the rasping of tongue against paw as he groomed himself (right) and the crashing of a branch as he marked it with facial-gland scent (below). Later he let me kneel in his path, eye to camera, as he strutted into the spotlight.







ROUGH LOVE Mating accomplished, Tjololo springs backward off his partner before she can turn on him. Cat copulation is often aggressive: Barbs on the male organ may stimulate ovulation but likely also cause the female pain. Still, during her weeklong estrus she'll mate with him hundreds of times before the pair part ways.

MALA MALA undulates with hills and gullies, its thick bush punctuated by patches of open ground. Some 35 leopards thrive on the reserve's diverse prey, abundant fresh water (the Sand River runs through it), and natural cover. Hundreds more live in Kruger (map). Tjololo's 14,000-acre territory encompasses four females' domains and accommodates the occasional young male seeking his own land. Leopards forgo no meal—fresh kill, carrion, even insects. At about 150 pounds, five-year-old Tjololo is powerful, able to hoist an animal twice his weight into a tree (left). Out of scavengers' reach, this impala will nourish him for days, while pools of rainwater quench his thirst (below). He'd emerge soaked from dew-coated grass, so I'd smile to see him sidestep puddles, catlike, to avoid wetting his feet.

HUNT'S END

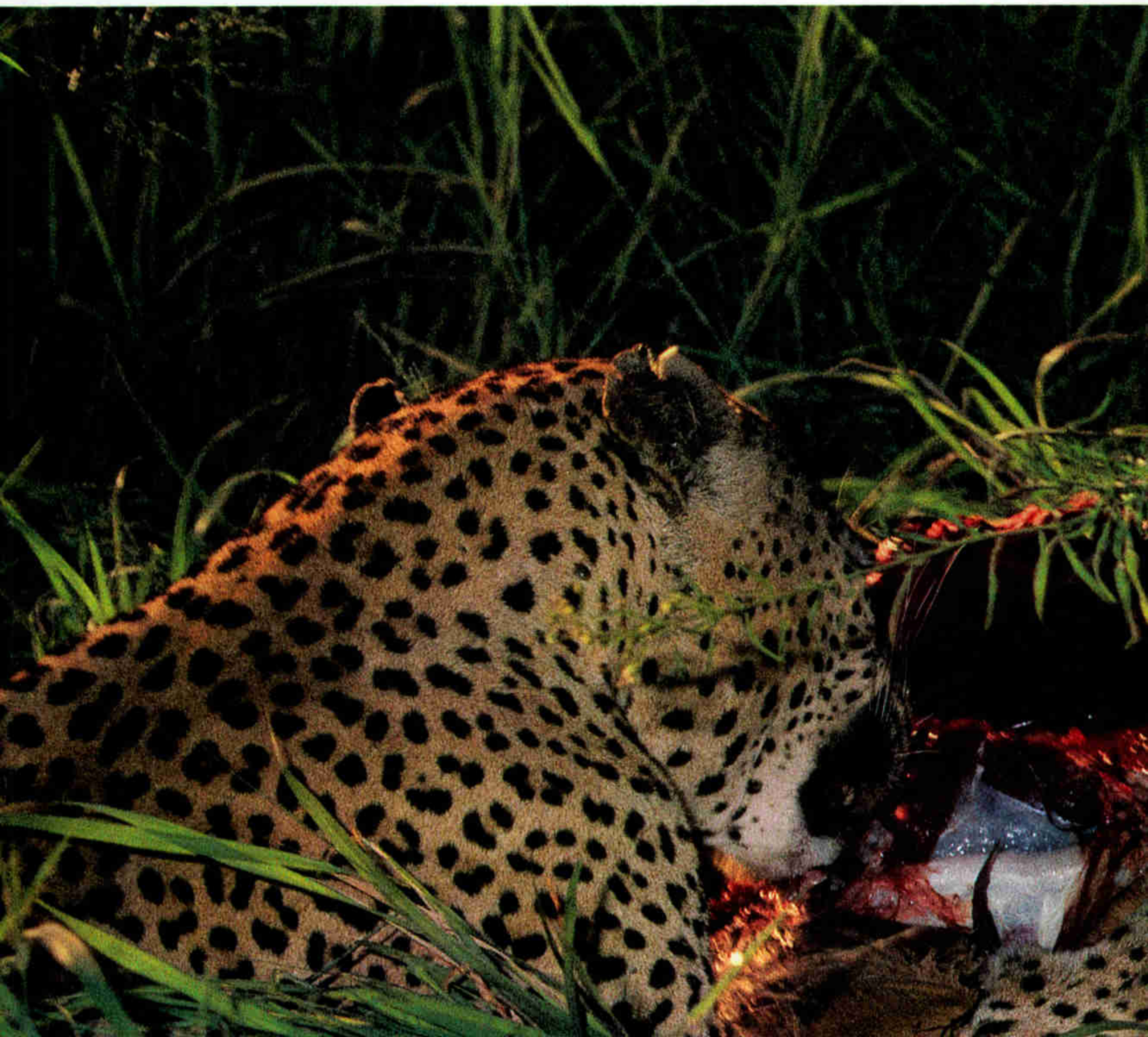
Death grips a glassy-eyed impala by the throat, patiently waiting out the flailing of its hooves as it suffocates. Moments before, Tjololo stalked in the darkness—body crouched, ears flat—to within striking distance, leaped from the side to meet the bounding impala in midair, and took it down.

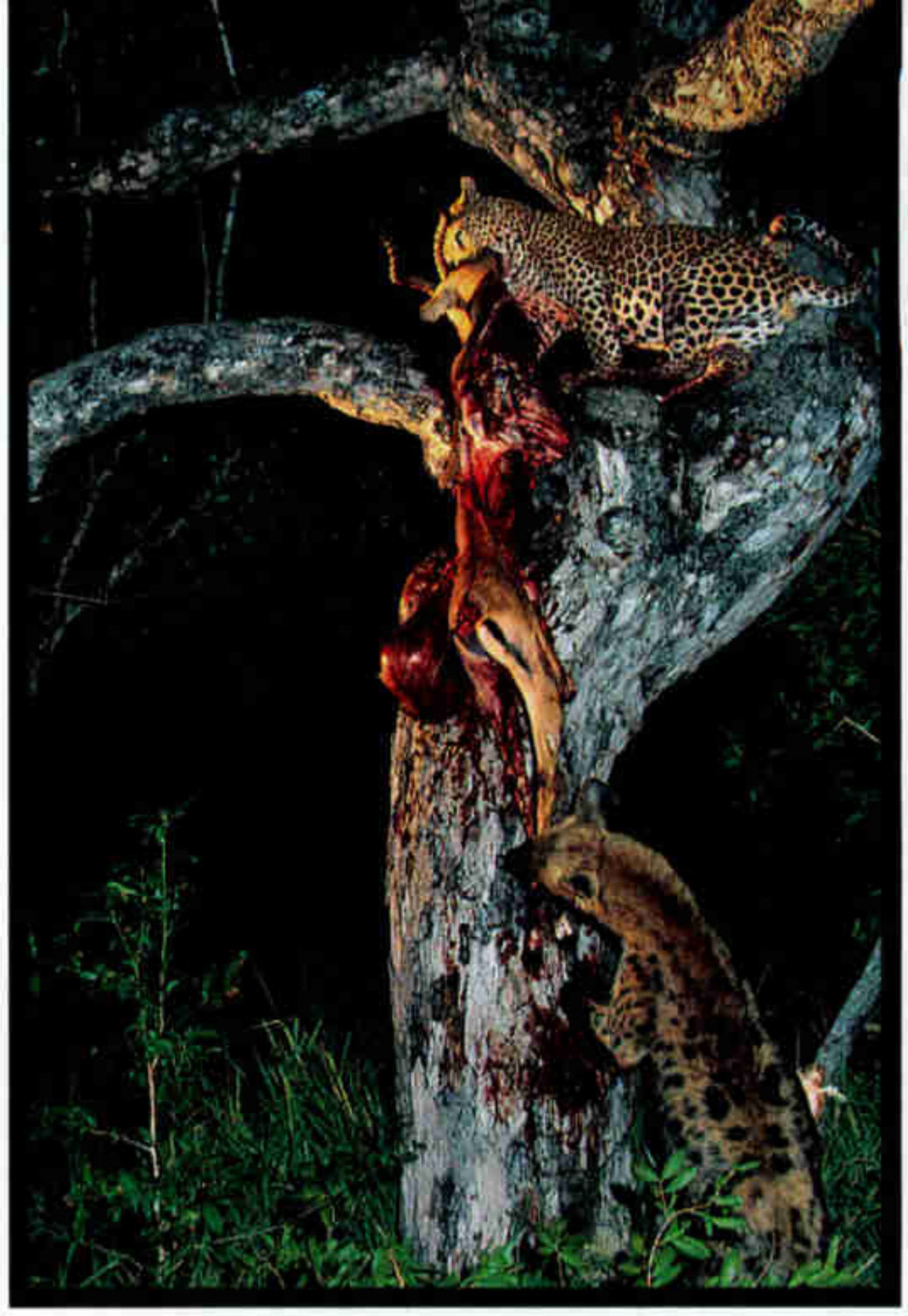
THEIR COMMON ENEMY, hunger, prevents Tjololo and a hyena from abandoning a fresh kill. In a bloody tug-of-war the cat—attempting to stash the impala—and the spotted hyena tore at the carcass from either end (far right) until it fell in a heap on the ground, where the two set upon it, ravenous for meat (below). Not until four more from the hyena's clan arrived did Tjololo back away. Another day it took only two of these powerful opportunists to tree Tjololo (one visible, right). A lion, the leopard's most dangerous foe, can do the job solo—then snag the smaller cat's quarry or a vulnerable cub.

Like all big cats, leopards face threats other than their natural competitors. Poachers and sport hunters take their toll, as do farmers who kill predators to protect livestock. Even more deadly is habitat loss. *P. pardus* is perhaps the most widespread of wild felines—living in much of Africa, the Middle East, and parts of Asia—but many leopards now exist in fragmented populations on the edges of human civilization. Although they are still abundant in sub-Saharan Africa, solid estimates of their numbers are lacking. Even where they seem to thrive, their future is far from secure.

MORE ON OUR WEBSITE

Watch an interview with Kim Wolhuter and listen to a leopard's call at **nationalgeographic.com/0110**.

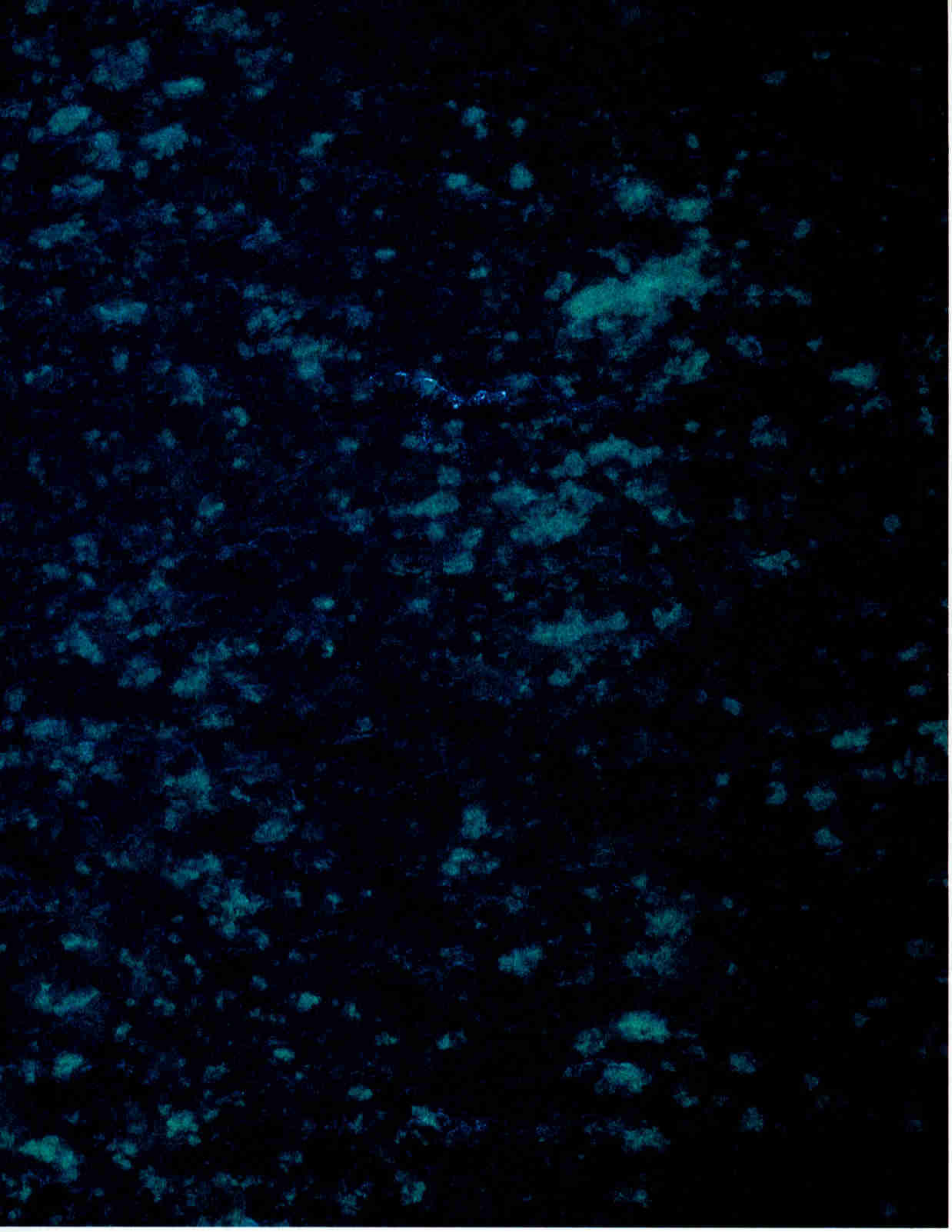




BURNED-OUT Controlled burns in Mala Mala leave the ground scorched and a leopard without cover. As Tjololo stalked a duiker, noisy monkeys revealed him. Abandoning the hunt—tail curled and tense as if signaling his irritation—he lowered his head and moved on, letting me escort him, once again, into the new day. □

A dhow carries fishermen across coral-littered shallows off Kenya's northern coast. For centuries boats

SWAHILI



like this linked cosmopolitan city-states on the shore of East Africa to Arabia, India, and beyond.

COAST

EAST AFRICA'S ANCIENT CROSSROADS

Article and photographs by
ROBERT CAPUTO

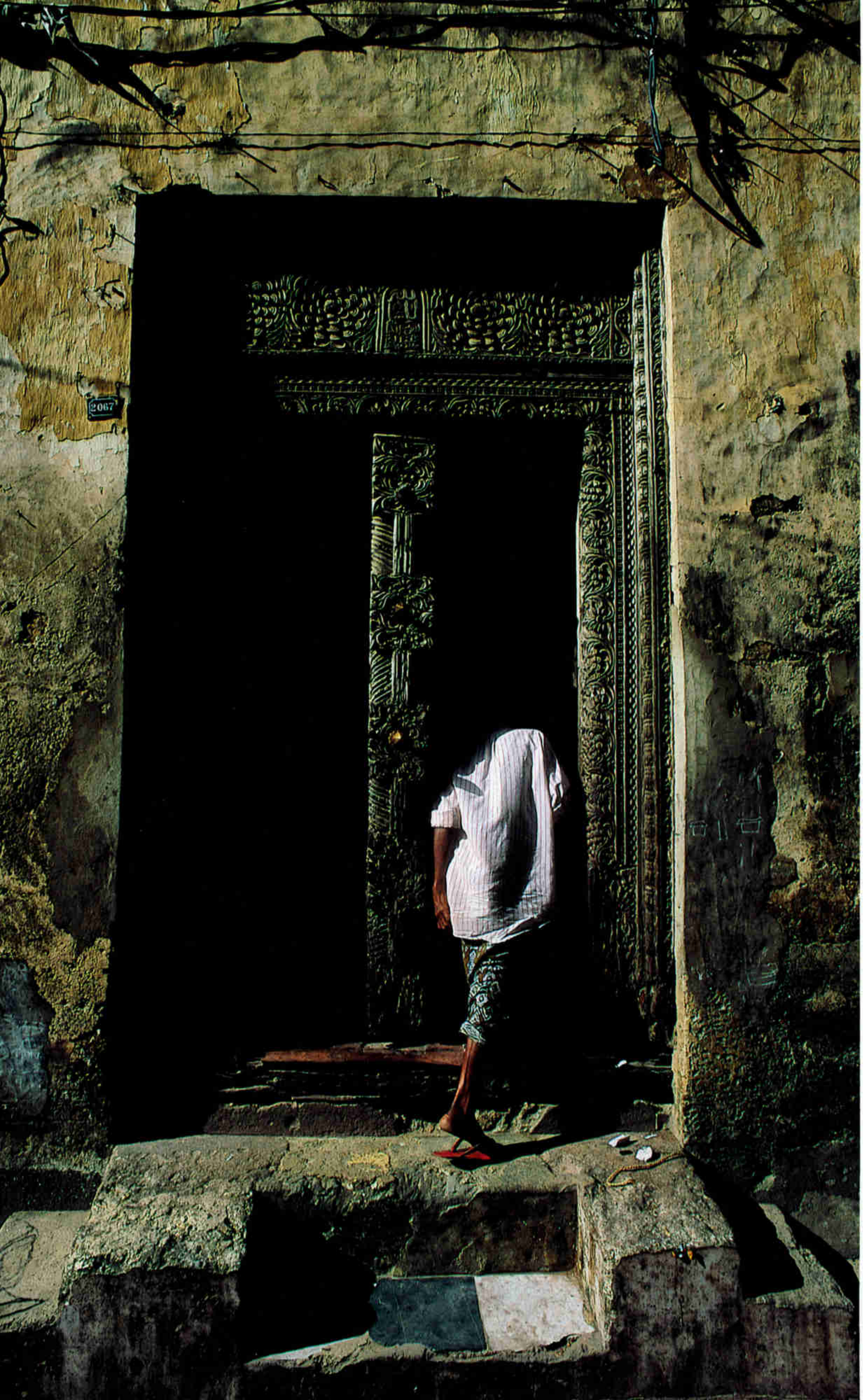
"Zanzibar, Dar es Salaam, Comoros, Mombasa, Mogadishu, Bombay, Mangalore. . . ." The names of places strewn along the rim of the Indian Ocean tripped like a melody off the old sailor's tongue. "I visited them all and more. From here in Africa we sailed with ivory, mangrove, coconuts, tortoise and cowrie shells. From Arabia we brought dates, whale oil, carpets, and incense. From India pots, glassware, and cloth. Trade was our life, you see."

Bwana Shafi Ahmed and I sat on the porch of the old fort in Lamu. Through an arched gateway we could see off into the harbor, dotted with lateen-rigged dhows. They carried people and goods to and from this island, just eight miles long and three miles wide—part of an archipelago off the far northern coast of Kenya. Below us in the town square groups of men, most wearing *kofia* caps and *kanzu* robes, sat talking in the shade. Boys with pushcarts scurried past donkeys laden with wares. Women, some covered head to toe in black *bui-buis* that revealed little more than their eyes, hastened by and disappeared into narrow alleyways. A call to afternoon prayer from a nearby mosque soared over the din of voices, braying animals, and clattering hooves. It was a scene that has changed little since Ahmed, who said he was "not less than 65 years old," left Lamu at the age of 15 and went to sea.

Veiled from view, women venture out to buy mangoes in Lamu. Devout Muslims, members of the Swahili elite maintain their houses as bastions of privacy and purity. In Zanzibar the ornate door of what once was probably a merchant's home separates the public realm of commerce, ruled by men, from the hidden realm of the household, ruled by women.

"Lamu prospered in those days," he said. "The wind in our sails made us rich, just as it did our ancestors. In the season, dozens of foreign dhows would arrive—booms a hundred feet long or more, great sails white against the sky. And at night! Hundreds of dhows big and small anchored in the harbor, their cooking fires shining like stars in the night.

"Oh, life at sea was hard work," he continued. "It could take us a month to sail from here to India—15 men in a 60-foot boat. Sometimes we would run into storms so bad we'd lose all hope of surviving. Sharks would ram the boat, nearly capsizing it. But the world was so big for us—seeing how other people lived, making friends in many different lands. The pleasures of being a sailor. . . ." A glimmer of fond remembrance lit up the old man's eyes as he excused himself and headed off to


2067

the mosque. "We will talk more of this later."

In its prime Lamu was one of a string of ports that stretched along the East African coast from Mogadishu to present-day Mozambique—ports that evolved into powerful city-states as they grew rich from Indian Ocean trade. For more than 2,000 years sailors like Ahmed sailed in and out of these ports on the monsoon winds. Arabian sailors arriving in Africa found good harbors, a sea full of fish, fertile land, and opportunities for trade.

Many of the Arabian sailors stayed to marry local women, and the melding is evident in the faces of the people who live here. Indeed, the interplay of African and Arabian languages and customs—the mingling of blood and ideas that permeated every aspect of life—created an urban and mercantile culture, embodied in the town of Lamu, that is unique to this coast. Even its name, Swahili, is an adaptation of the Arabic word for coast, *sawahil.*

THE SWAHILI CITY-STATES flourished between the 12th and 18th centuries, when ships from Arabia, India, and even China called at their ports to carry away the goods that made the Swahili rich—gold, ivory, slaves brought from the African interior, and agricultural products grown on slave-labor plantations owned by the towns' wealthy merchants.

Until the 1970s and early '80s, when Ahmed sailed, Lamu's most important export was mangrove. Cut in the extensive swamps of its archipelago, the long, straight poles—termite- and rotproof—were used locally for building houses and were shipped to treeless Arabia as well. Huge stacks of mangrove poles lined the waterfront; their harvest and shipping provided not just export earnings but also jobs for hundreds of people.

"Dhows could carry only a limited amount of mangrove and could sail to Arabia only from July to September, on the Kusi winds," explained Hussein Soud El-Maawy, one of the men I met one evening sitting outside a seafront mosque discussing Lamu's affairs. "So it was a sustainable trade. But in the 1980s bigger ships started coming. Of course they could carry hundreds and hundreds of tons and could go and come any time of year. The swamps were very soon overcut. Now there is a ban on mangrove export. But it does not matter; the market is gone anyway. With the oil boom the Arabs can afford to import steel for their houses."

Lamu's harbor is too shallow for modern freighters and too

Zanzibar's old Stone Town juts into the Indian Ocean. Beyond its coral houses lie mud-and-thatch dwellings similar to those of the earliest Swahili. At least 2,000 years ago Africans from the interior settled on the eastern coast (map) to farm and fish, later adopting Islam from Arab traders. By A.D. 1000 their villages had grown into competing city-states. The leading Swahili traders, consummate middlemen, sold gold, ivory, and slaves to Asian merchants whose ships arrived on monsoon winds.

THE INTERPLAY OF AFRICAN AND ARABIAN LANGUAGES AND CUSTOMS— THE MINGLING OF BLOOD AND IDEAS— CREATED A CULTURE THAT IS UNIQUE TO THIS COAST.

far from Kenya's population centers to be useful as a port anymore. That function was taken over by Mombasa, another former Swahili city-state to the south. When the mangrove trade declined, Lamu further deteriorated economically.

"There isn't much work here," said El-Maawy. "Many of our young people have been forced to leave to look for jobs—to the mainland, even to Arabia. Without an economy we cannot survive. And of course those who leave can easily forget our way of life."

In recent years the romance of the old town and the lure of the beach have attracted tourists, who are now an important part of Lamu's economy.

"But tourism is a double-edged sword," El-Maawy said. "People come here because they like to see the way we live. We are very traditional, even conservative. We do not drink alcohol; we prefer that people dress modestly. The tourists bring money, which we need, but they also bring influences that are difficult for our young people to resist. Just recently I had to ask a visitor to please wear a shirt while he was in town.

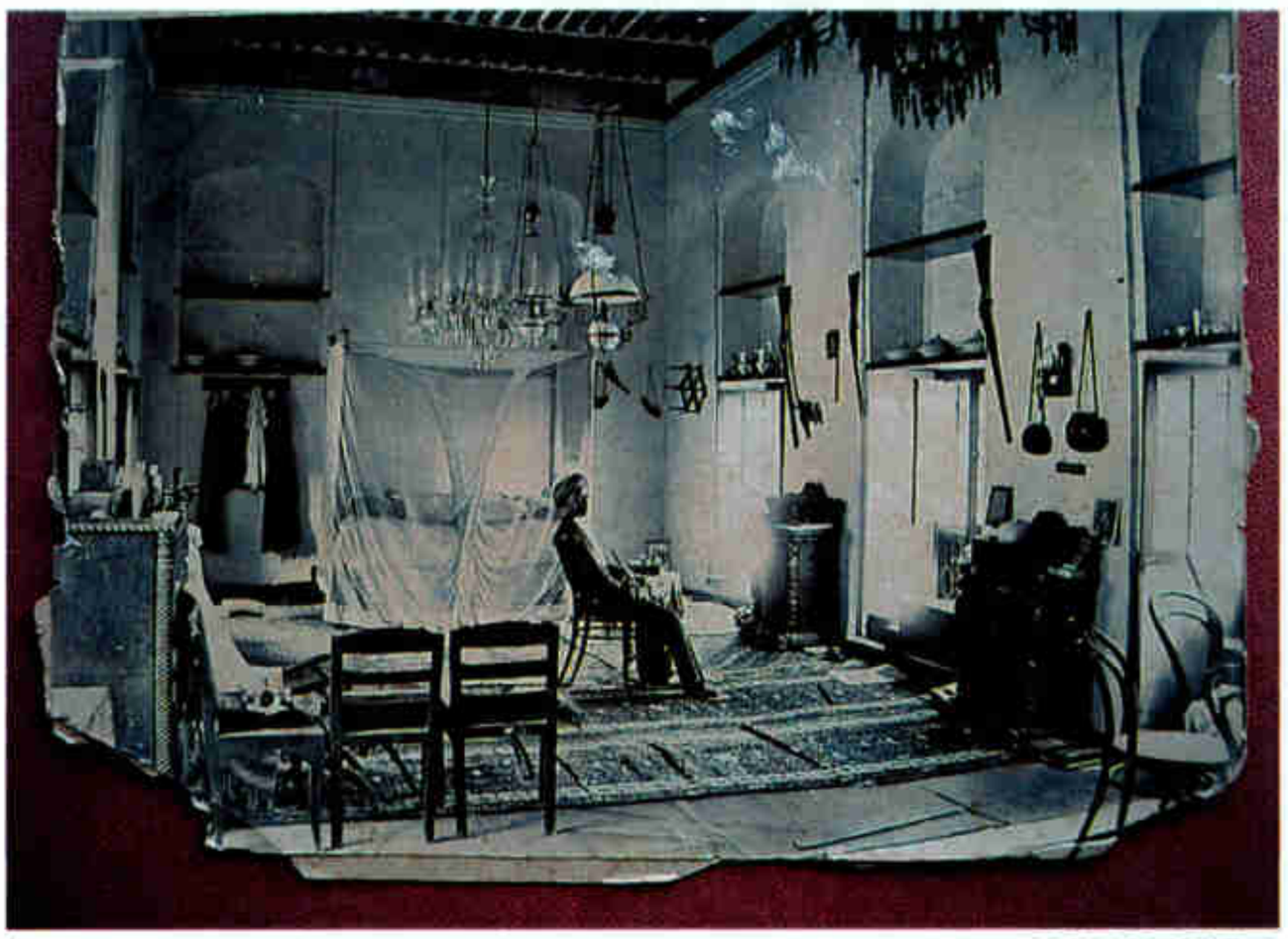
Many Zanzibaris—such as these men hashing out affairs on a streetside bench—are descendants of a wave of Arab immigration dating from the 1700s, when East Africa fell under the control of Oman. The new rulers formed partnerships with Indian merchants, who built first-floor shops and second-story homes that still line a street in Zanzibar.

"And the tourists attract people from the mainland who are after their money too. Between our young people leaving and others coming from the mainland, only about 50 percent of the population is actually from Lamu. This puts us in danger: The tourists help us survive, but their money and ways may kill the thing they come here to see. We elders must walk a fine line between accommodating them and maintaining our traditions."

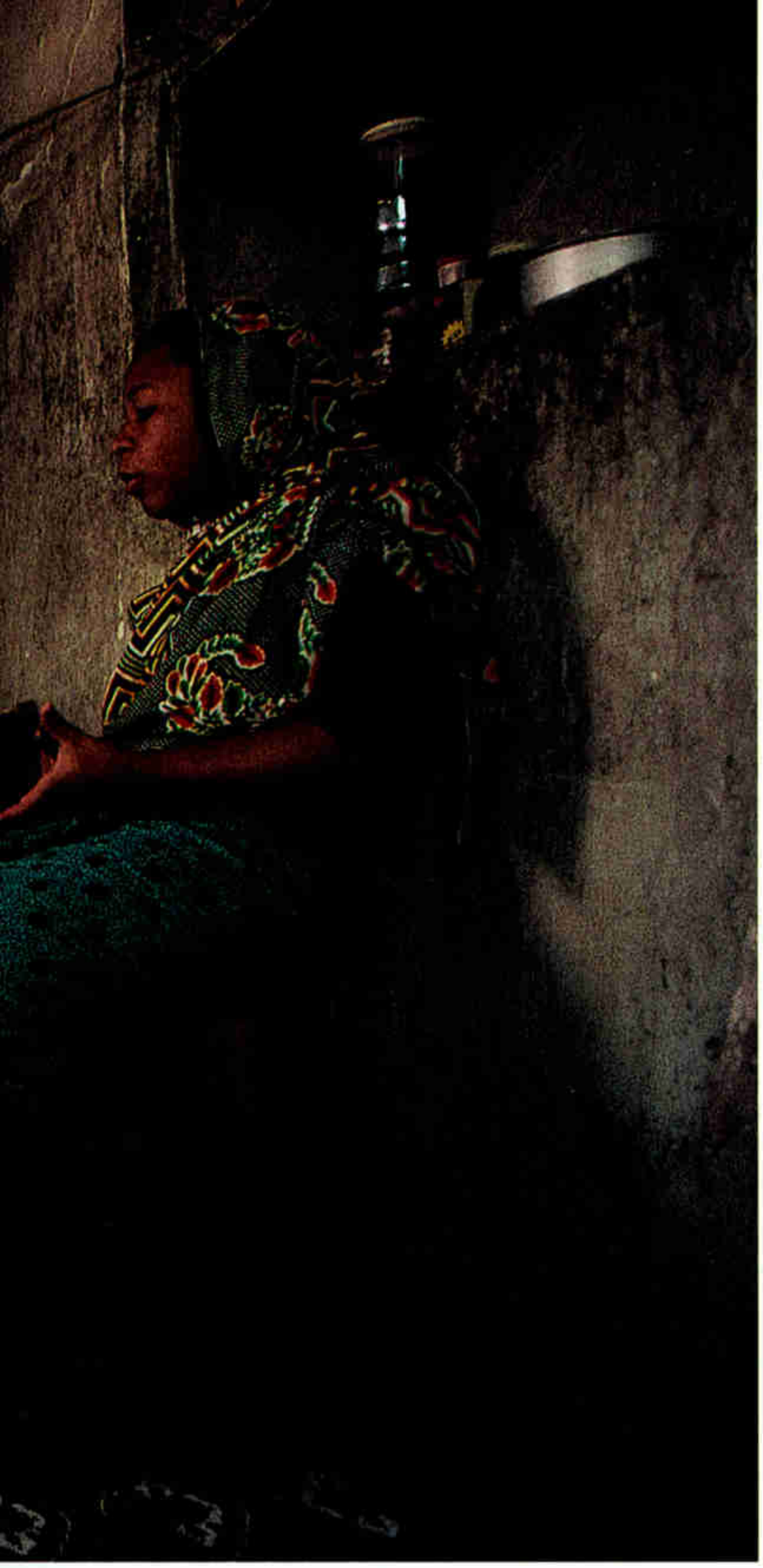
Lamu, geographically isolated, has managed to survive into modern times with many of its customs and traditions intact. Most of the other city-states have disappeared—the coast is littered with the ruins of what were once prosperous and populous towns.

The few towns besides Lamu that have survived bear little resemblance to the places they were. I visited Mombasa, once one of the most powerful city-states, but could find little of its original Swahili character. Now Kenya's main seaport, its old town has been swallowed up by urban sprawl. Malindi, also on the Kenyan coast, became a popular tourist destination in the 1970s and lost itself to resorts and the influences of tourist money so feared in Lamu. Swahili people I spoke with everywhere lamented the loss but saw it as the inevitable price of joining the modern mainstream.

SOME 50,000 AFRICANS WERE SOLD IN ZANZIBAR'S NOTORIOUS SLAVE MARKET EACH YEAR. SO LUCRATIVE WAS THE TRADE THAT THE SULTAN OF OMAN MOVED HIS CAPITAL TO ZANZIBAR.



ZANZIBAR ARCHIVES



Sheltered in domestic seclusion, women apply henna in Zanzibar. Swahili adorn themselves to express inner purity, a quality that once gave leading families so much authority that they could govern without armies or kings. Under the Omanis, this changed: A sultan ruled from a palace in Zanzibar, where a prince sat in his quarters a century ago (left).

ONLY ON THE ISLAND OF ZANZIBAR, which once dominated the entire coast, did I find a modern city that still protects its Swahili roots.

Zanzibar, along with neighboring Pemba Island, joined with Tanganyika in 1964 to form the United Republic of Tanzania and is only 40 miles from Dar es Salaam, the capital. Zanzibar City is a political and administrative hub, a modern city of 160,000 people heavily involved in modern commerce. Freighters as well as dhows call in the harbor.

"We are a seafaring and merchant people, nurtured by contact," Professor Abdul Sheriff explained when I met him in a café overlooking the Indian Ocean. "We are a blend that has occurred over a very long time in a natural way, an organic growing together of external and internal influences. In the past it was a blend of African and Arab. Now it is a blend of traditional and modern. All you have to do is look around to see it."

The blending of which Sheriff spoke is everywhere present in Stone Town, the old part of Zanzibar City. Like Lamu, Stone Town is a maze of alleys and looming coral-block houses that does not permit cars—though you have to watch out for the motorcycles that roar through the narrow streets.

The men who sit outside the Stone Town mosques in the evenings show the same mingling of cultures as those in Lamu. And not just from the distant past:

"I was born in Oman, in Arabia, but I left there when I was a boy," Abdallah Sleyum told me in a small coffee shop off one of the alleys. "I sailed in an Omani dhow for two years, then took a Zanzibar boat full of cloves to Bombay. Then I settled in Bombay for five years, sailing between southern Indian ports. In 1949 I settled here and married. Since then I have been a Zanzibari."

I wondered if it had been difficult to be accepted in Zanzibar, if people treated him as an outsider.

"Not at all," he replied. "It is the history of this place. If you adopt the culture and learn the language, you will be accepted. And it is easy to learn the language if you marry."

Sleyum is part of a long tradition: Omani Arabs played a major role in the history of the East African coast. Omani forces ended Portugal's brutal 200-year occupation of the coast in 1698, only to set themselves up as colonizers in Portugal's stead. By conquest and treaty they united independent city-states, including Lamu and Mombasa, into a single, if fairly loose,

political and economic entity for the only time in their history. The fort in Lamu where I'd talked with Bwana Shafi Ahmed was completed in 1821 as a garrison for Omani soldiers seeking control of the northern part of their realm.

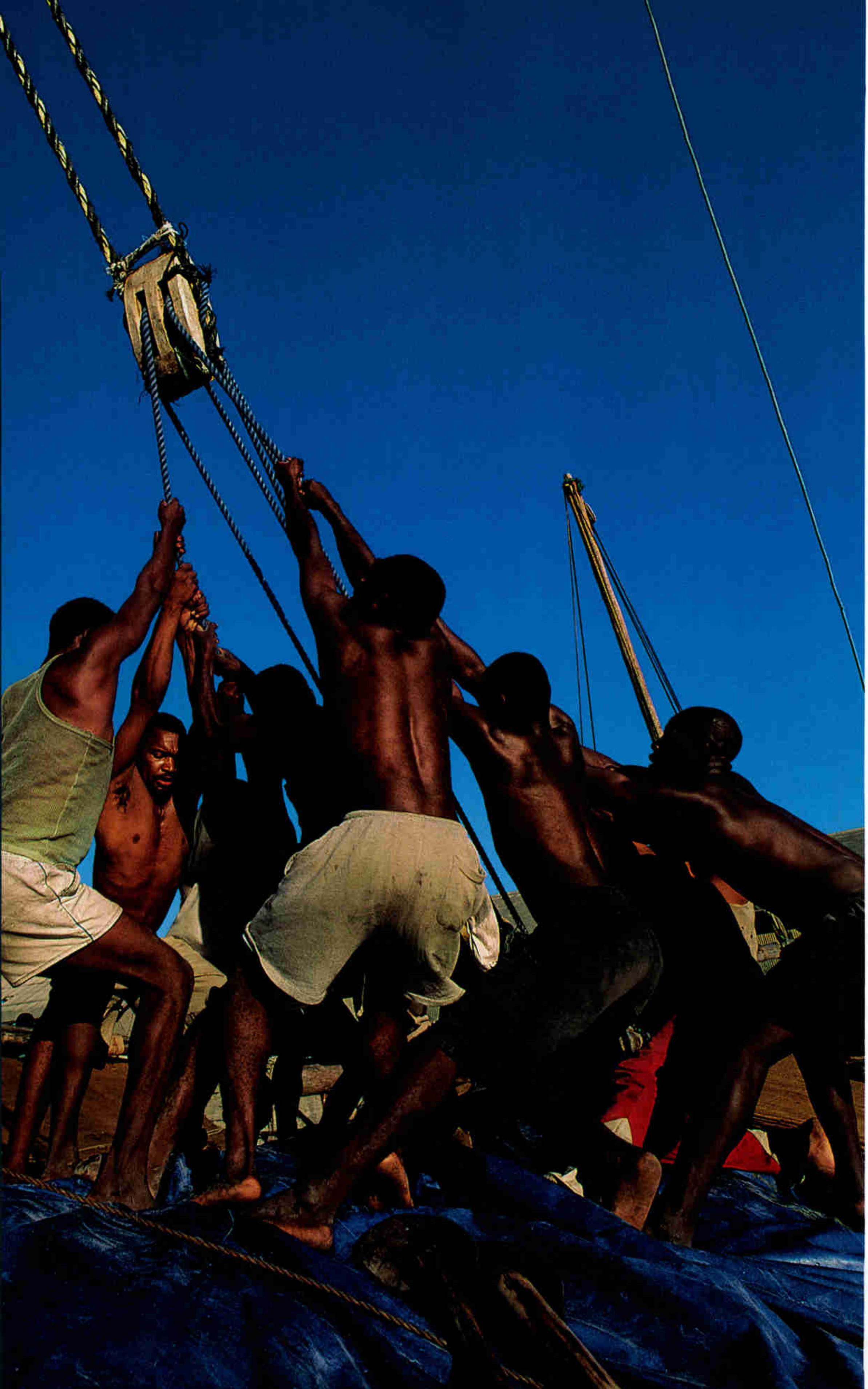
The Omani rulers introduced cloves and greatly increased the slave trade. By the mid-1800s some 50,000 Africans were sold in Zanzibar's notorious slave market each year, and about half of the population of Zanzibar and Pemba Islands —which together produced 95 percent of the world's cloves— were slaves. So lucrative was the East African trade that the Sultan of Oman moved his capital to Zanzibar in 1832, establishing a dynasty that lasted there until 1964.

Zanzibar was a center for exploration as well. It was here that Livingstone, Stanley, Burton, and other Western explorers recruited porters and guides, stocked up on supplies and trade goods, and set off in search of the source of the Nile. And it was to here, weary, that they returned. They were intrepid men— some spending years exploring the African interior—but they all followed trails well-worn by slave and ivory traders, and all of them would likely have perished from disease or starvation if not for the aid of the Zanzibaris.

Once they carried swords; now men in Lamu brandish sticks in a traditional dance performed during Maulidi, Muhammad's birthday celebration. In Zanzibar (facing page), crewmen strain to raise the sail of a dhow. Such boats still carry goods and people short distances, but modern cargo vessels have taken over the routes to Arabia and India.

I too would have been lost without the aid of the Zanzibaris—if only in the alleyways of Stone Town. In Lamu I could just head downhill and know I would eventually run into the sea. But Stone Town is flat and much larger, with alleys that twist and turn in a serpentine maze. I wandered map in hand and frequently asked directions. The locals were always helpful—a merchant sitting outside his shop, a passerby, the men playing dominoes in a square—and they were always amused when I showed up a few minutes later having walked in a circle. But what a wonderful place to get lost.

Most of the buildings in Stone Town were built in the 19th century, during the time when the sultan's agents penetrated deep into the African interior and established entrepôts as far away as Ujiji, on the shore of Lake Tanganyika. The buildings are full of history. Beit al-Ajaib (House of Wonders), once the sultan's palace, hints at the island's former prosperity, its four veranda-encircled stories still dominating the waterfront. Not far away, run-down and unmarked, stands the house of Tippu Tib, Africa's most notorious ivory and slave trader. The Anglican cathedral, built in 1877, occupies the site of the old slave

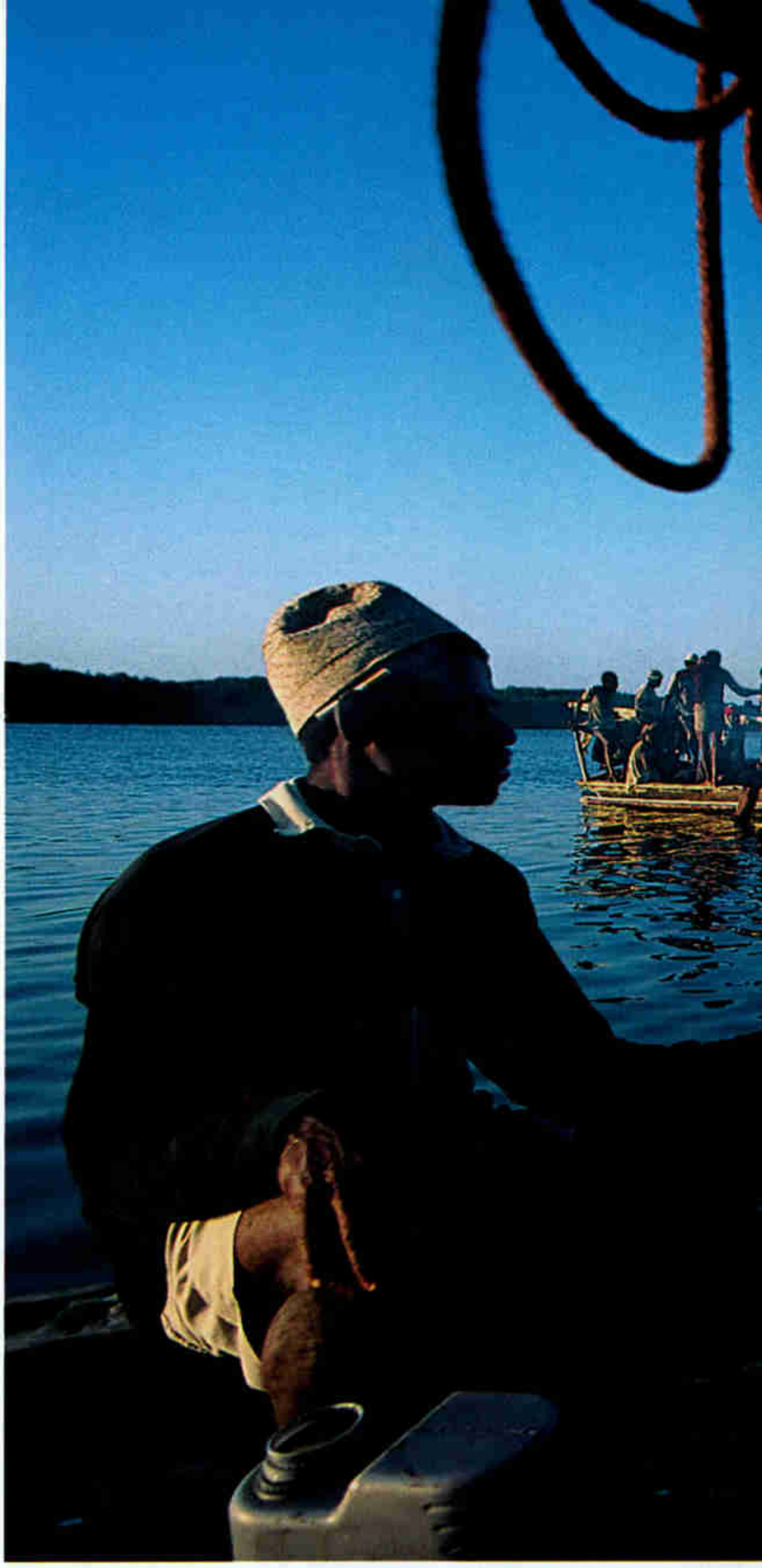


market—the altar stands where the whipping post was, the crucifix is said to be made of wood from the tree that marks the place where David Livingstone's heart is buried, the tower bell was the gift of a Muslim sultan.

The great wooden doors on many of Stone Town's houses bear carved inscriptions with Arabian and Indian motifs. Intricate lattice-work balconies speak of the time, not so long ago, when women remained hidden. It is behind these reminders of the past that the unique character of Zanzibar is revealed. One great door opened on a shop selling spices from the island's gardens, another on an air-conditioned business center offering fax and Internet connections.

"The trick is to find a balance," one young man told me. "I have an education and a professional job, but I share a common feeling with the old men. I go to the *tarab* to hear traditional music, and I go to the disco. Sometimes I wear a kanzu, sometimes Western dress. The elders worry about this, but we do not see it as a contradiction."

"Old people always feel threatened by new things—not just here but all over the world," said Sheriff when I asked him about modern influences. "They feel that culture is a fragile thing, to be preserved intact. But you have to remember that Swahili is a dynamic culture. It has never been pure. Since the beginning, it has incorporated foreign elements, and it will continue to do so."



Living off the sea, fishermen break for a meal while unloading their catch at Kiwayuu Island. Fishing continues to provide a modest income for some Swahili. Tourism creates low-wage jobs for others, though most profits go to outsiders. In Zanzibar, shallows nurture a cash crop of seaweed, which is exported for use in many products, cosmetics to ice cream.

THE DYNAMIC NATURE of Swahili culture was fully evident when I returned to Lamu for Maulidi, the celebration of the Prophet Muhammad's birthday. The day is celebrated all over the Muslim world, but Lamu is famous for both the piety and the gaiety of its four-day observance, which combines traditional prayers and sermons with popular entertainment. Thousands of visitors throng the town—not just from villages on other islands in the archipelago but from mainland Tanzania, Uganda, Sudan, Somalia. I even met a group of pilgrims from Canada.

"We are proud of our Maulidi. It helps preserve our culture, and it helps us maintain our identification with the larger Swahili world," explained my friend Hussein Soud El-Maawy. "It is the only time we gather together. We talk about the teachings of Habib Swaleh, the holy man who first introduced music and dance to our Maulidi—a heretical idea at the time. But he knew

"THE TRICK IS TO FIND A BALANCE," ONE YOUNG MAN TOLD ME. "I GO TO THE *TARAB* . . . AND I GO TO THE DISCO. SOMETIMES I WEAR A KANZU, SOMETIMES WESTERN DRESS."

these elements would bring more people to hear about Islam."

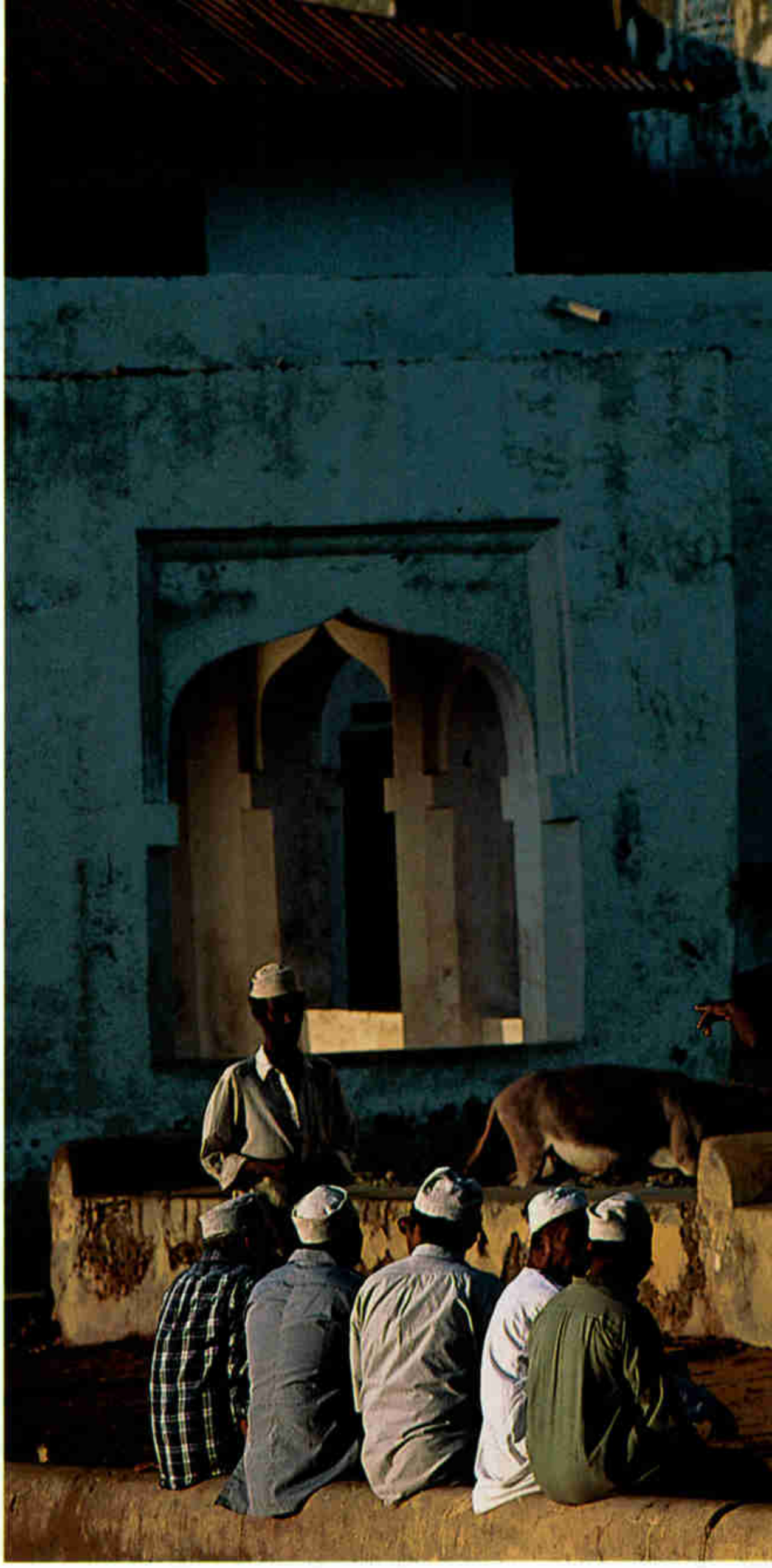
Lamu was transformed for the event: The alleys were swept clean and draped with lights and bright banners. Dhows flying brilliantly colored flags anchored along the waterfront. Newcomers announced their arrival with singing and blowing of horns. Crowds of Lamuans flocked to the water to greet their visitors and hear the latest news. All wore their finest clothes; the women's hands and feet bore elaborate henna designs.

The festivities began quietly with small celebrations in private households. But soon thousands of people moved to an open area near the Riyadha mosque. After that the days were filled with donkey and dhow races, soccer, poetry readings, a traditional board game called *bao,* and henna-painting competitions.

In the late afternoons everyone gathered at the mosque. They danced until six, then ate and gathered for lectures and prayers, when the boisterous crowd transformed into an orderly congregation. On Thursday, for the recitation of the Grand Maulidi, the prayers continued long into the night.

On Friday afternoon the men gathered in neighborhood or village groups in the square to begin a procession to the tomb of Habib Swaleh in a cemetery south of town. They set off at four playing drums and tambourines, waving banners and palm fronds, each group singing and playing its way through narrow alleys lined with cheering onlookers. At the tomb all waited quietly as the elders paid their respects to Lamu's holy man.

The final procession back to the square was a more lively affair—the men marching along the waterfront, where it seemed that every woman in Lamu had lined up to watch. Caught up in the joyous crowd, I thought how odd it was that this same celebration was once feared as heretical—a threat to tradition. And I remembered what Professor Sheriff in Zanzibar had said about culture and change: "Swahili history is about adaptation and incorporation. We have always been middlemen—between the land and the sea, the producers and the buyers, the African and the Arabian. That is not a concern; it is our strength. We will survive. Oh, Swahili culture may not be quite the same tomorrow as today, but then nothing living is." □



Life proceeds at a donkey's pace along the waterfront in Lamu. The growing dominance of the industrial West, with its demand for luxuries like pianos, brought a flood of ivory through ports such as Zanzibar during the 1800s (right) but also signaled their eclipse. Trade hubs became backwaters. Yet the Swahili remain, old wealth gone, rich culture enduring.

MORE ON OUR WEBSITE

Robert Caputo shares more about this land of tropical spices and stifling heat in a video interview at **nationalgeographic.com/ngm/0110.**

ZANZIBAR ARCHIVES

"WE HAVE ALWAYS BEEN MIDDLEMEN—BETWEEN THE LAND AND THE SEA, THE PRODUCERS AND THE BUYERS, THE AFRICAN AND THE ARABIAN. . . . IT IS OUR STRENGTH."

ADJUNTAS, PUERTO RICO

00601

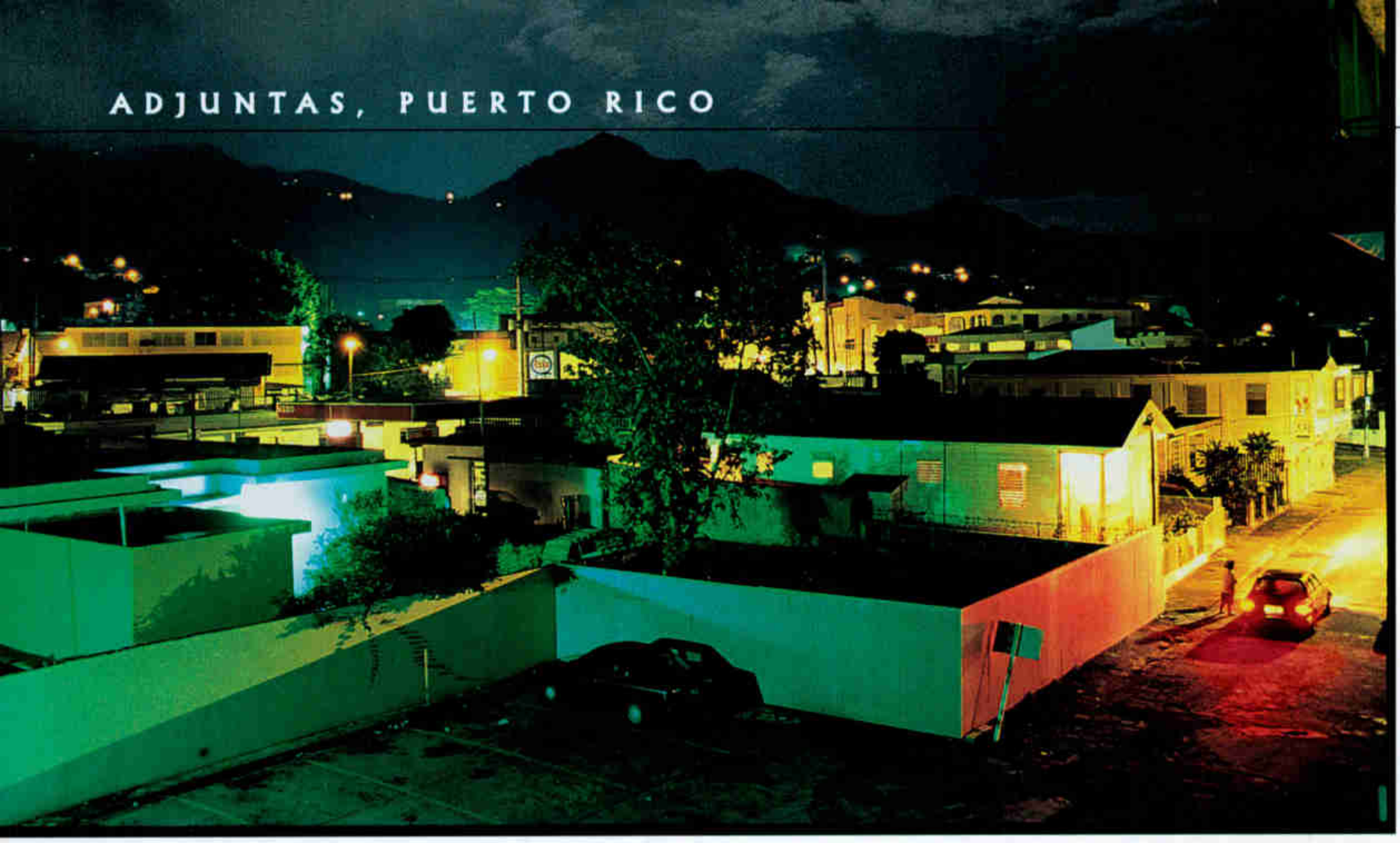
Strong Coffee, Sweet Songs

BY LINDA GÓMEZ

PHOTOGRAPHS BY AMY TOENSING

On a warm Friday night in the highlands of Puerto Rico, the songs and laughter flow as easily as the beer. Ride on in. It's been a long week.

ADJUNTAS, PUERTO RICO



There's a mythical air to Adjuntas, a coffee town in the Valley of the Sleeping Giant high in the mountains of Puerto Rico. Still, it was a surprise when Yúbert Rodríguez, a fifth-generation Adjunteño, pointed to a nearby mountain and said, "My land is at the top of Olympus. Want to see where the gods live?"

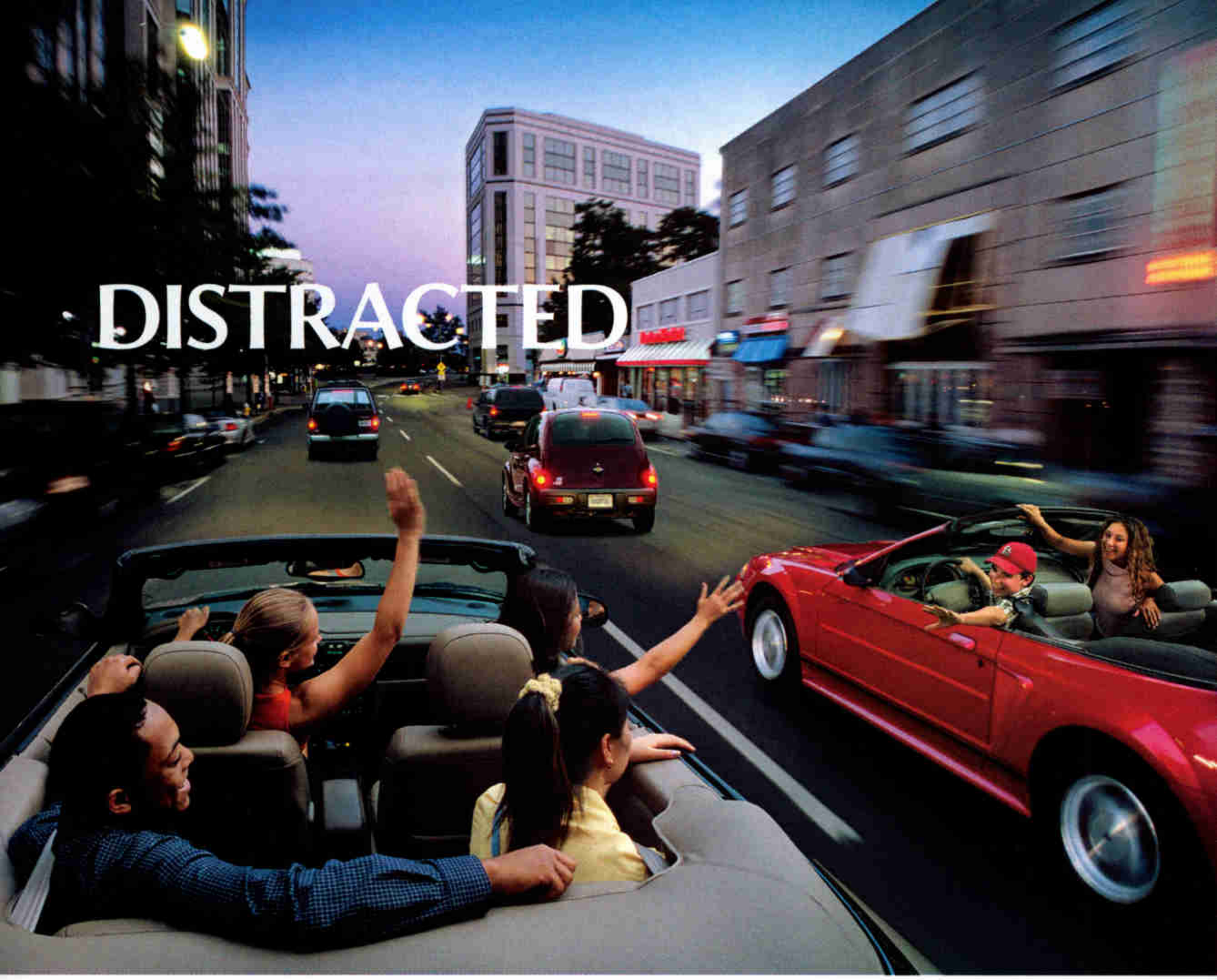
The 50-year-old schoolteacher drove up a steep road into the tropical forest, then hiked past gigantic ferns and philodendrons to a small grotto full of orchids and bromeliads where a spring burbled beneath smooth flat stones. He bought the land as a young man to preserve it, and without felling a single tree he has created a garden that would make Eden blush. "The Indians called spots like this *yuquiyu*, a place where you feel the presence of God," he said. "These mountains are full of them. To protect and nurture one is a sacred joy."

Love of the land and its customs runs deep in Adjuntas, where folks say their families have lived "since forever" and formal good manners rule daily life. You smell it in the surrounding barrios, where whole pigs are spit-roasted at roadside stands, and taste it where visitors are offered shots of *pitorro*, an illegal moonshine made from sugarcane and buried in the earth for a year. You see it in the elegant Paso Fino horses paraded through town on holidays, and you feel it sitting in the large, gracefully landscaped plaza, with its amphitheater, fountains, courtyards, and stone benches.

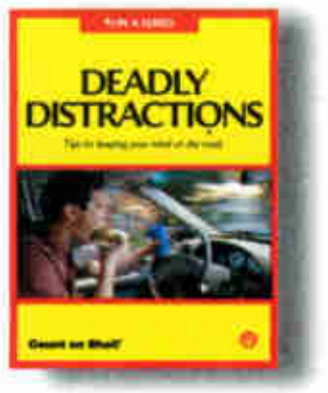
00601

TOTAL POPULATION OF ZIP CODE: 19,140
POPULATION OF TOWN: 4,980
NUMBER OF MOVIE THEATERS: None
NUMBER OF STONE BENCHES IN THE MAIN PLAZA: 65
RANK AMONG PUERTO RICO'S 20 COFFEE-PRODUCING MUNICIPALITIES: 2nd
CLAIM TO POSTAL FAME: 00601 is the lowest zip-code number permanently assigned to any geographic region in the United States.

By day Adjuntas's modest downtown is aflutter with business, including the sale of parakeets. By night, for fun, young Adjunteños drive a new road—across the mountains (above) to Ponce, a coastal city.



Are you keeping your mind on the road?



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Three blocks from the square, in the big pink-and-white house called Casa Pueblo, love of the land motivated locals to oppose a massive strip-mining operation in the eighties and nineties. The mountains surrounding Adjuntas are rich with gold, silver, copper, and zinc, and the Puerto Rican government had reserved roughly 55 square miles for mineral exploitation. International mining companies sought to extract ore from open pits.

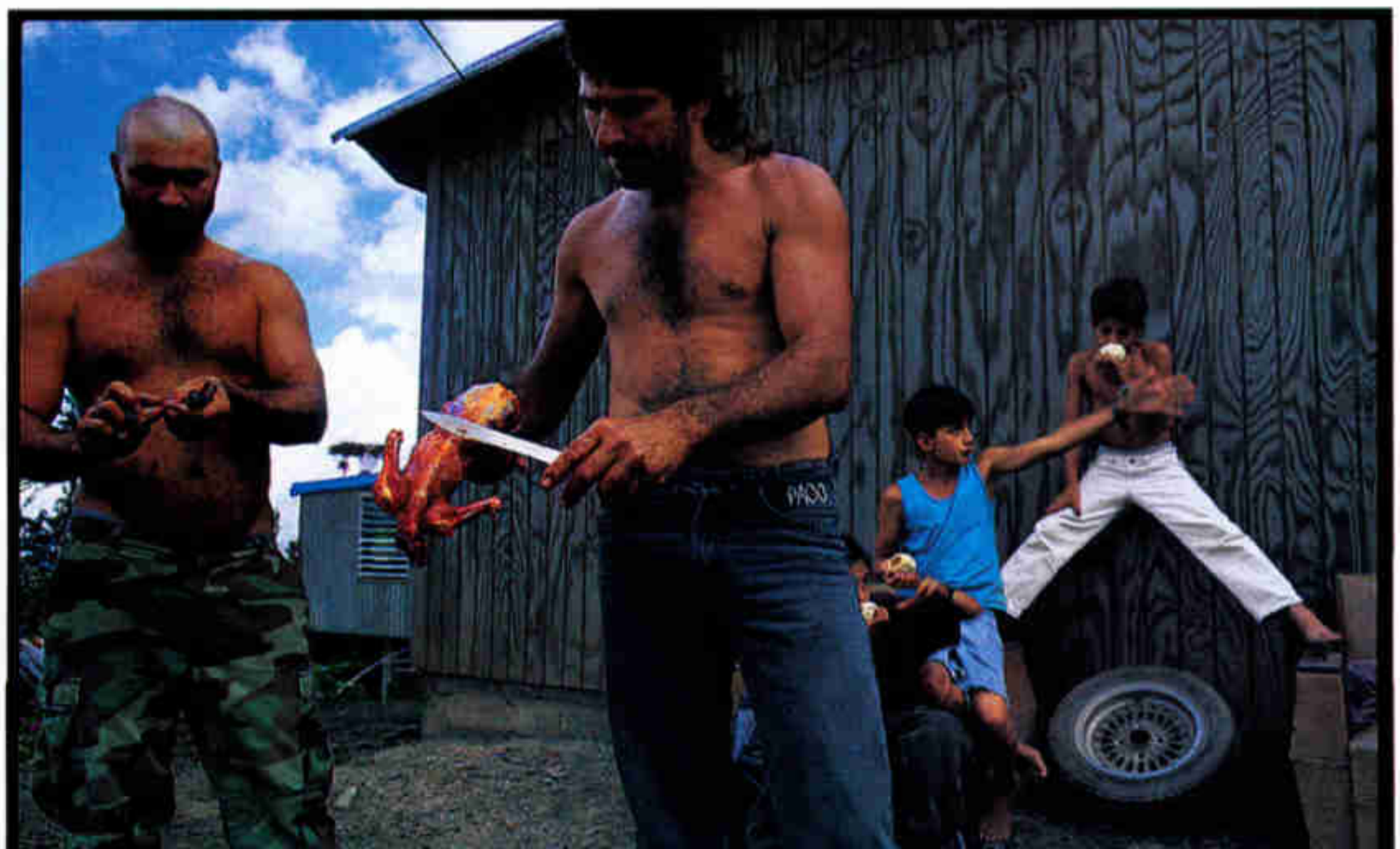
"Ecologically it would have been disastrous," said Alexis Massol, the 57-year-old founder of Casa Pueblo. "People understood and fought to protect the land despite the promise of jobs and money." Casa Pueblo evolved from an anti-mining coalition to a community group active in environmental, cultural, and educational affairs. "We were trying to figure out how to pay for our projects and be self-sufficient," recalled Massol, "when an old *jíbaro,* a hillbilly, pointed to the mountains and said, 'There lies the answer!' "

He meant the coffee growing there, for which Adjuntas is famous. Casa Pueblo began selling the strong, dark Café Madre Isla throughout Puerto Rico. The profits allowed the group to wage and win a campaign persuading the government to transform the mining zone into a national park—El Bosque del Pueblo, or People's Forest—protected by law and managed by Casa Pueblo. Inaugurated in 1998, the park has hiking paths designed by local students and a reforestation program allowing young and old to plant trees where land had been excavated.

"Learning to manage the forest has been a kind of reincarnation for us," said Tinti Deyá, Alexis' wife and co-founder of Casa Pueblo. "It's another world where we're like children doing everything for the first time, except in our case we're grandmothers."

Grandmothers are everywhere in Adjuntas, and they're all respectfully addressed as Doña. Lala Echevarría, an 85-year-old great-great-grandmother, was born on Calle Canas, the oldest street in town, where she lives in a small, immaculate home. Doña Lala grew up before electricity and running water and remembers when the first car arrived in Adjuntas. "I was always working, hauling water, finding firewood, tending the chickens, pigs, and cow," she said of her childhood. "There were

Traditions stretch back centuries to the mountains of ancestral islands.



A cockfight demonstration sheds light on a local tradition for students but sheds little blood, due to plastic sheaths slipped over the cocks' spurs. Baring his blade, Berto Caraballo preps a chicken for the pot.

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16 of us. We washed our clothes in the river, and we cooked on an open fire. We had benches instead of furniture. For meals, we kids sat on the floor and ate off the benches."

Doña Lala was working as a maid when she met and wed the love of her life, Mariano the mechanic. They had 13 children and shared 44 years before he died in 1983. She points to the dozens of photographs of four generations of descendants that fill her tiny home. "Mariano never ate before the children," she said. "Not once. He needed to know they'd eaten before he'd touch a bite."

Traditions in Adjuntas stretch back centuries to the mountains of ancestral islands such as Mallorca, Tenerife, and Corsica. People play the old songs in the countryside and in little stores, like Lauro Yépez's place, where men gather to swap stories and drink beer. When troubadour Tato Ramos appeared, word spread fast, and the store filled with working-class men clapping, tapping, and nodding to the music. Ramos's voice took on the nasal, plaintive wail of flamenco as he improvised lyrics in the 500-year-old Spanish *décima* format of ten verses. Ramos learned the art from his father and was now teaching his son. Ramos sang about growing coffee, welcoming visitors, ignoring parental advice, and losing oneself to drink, all themes requested by store patrons.

"This is a forgotten art," Yépez said. "People give him a theme, and he composes the song, in proper rhyme, on the spot." He poured the singer a shot, which he gratefully slugged down.

I told Yépez I'd heard about troubadours from my 88-year-old Spanish father but had never seen one before. Yépez smiled and pointed to my recorder. "Bring that to your father," he advised as we said good-bye.

Back home I played the music for my dad, who has Alzheimer's disease. The recording was scratchy and gravelly. Dad grabbed the tape player from the kitchen table and lifted it to his ear to better hear the troubadour's whiny cant about love and life. His dark brown eyes twinkled with recognition. He nodded his head, smiled, and said, "Oh yes, this I remember, this I remember. . . ." □

Stop by El Andino and you'll hear doleful songs about loneliness, improvised ditties on just about any theme, and (if you're lucky) a melodic farewell to thank you for visiting this mountain home.

MORE INFORMATION

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Final Edit

SOUTH AFRICA

Leopard Lounge

"The mother knew me, so they were totally unconcerned with my presence," filmmaker and photographer Kim Wolhuter says of this leopard family. Kim has made two films about wild leopards in South Africa's Mala Mala Game Reserve. The first, *Beauty and the Beasts,* stars this adult female, Beauty. For the second, *Stalking Leopards,* the crew wanted to follow an adolescent male. "Young males think they're invincible," says Kim. "They'll pester rhinos and buffalo—it's very funny." Beauty's cub Smudge, here about three months old, "was our man," recalls Kim. Sadly, Smudge died of unknown causes before the cameras rolled. "It was a somber moment when we found him. We had looked forward to seeing him grow up." Tjololo, a restless adolescent, became the star of the film and the story "Tracking the Leopard," beginning on page 90.

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You can send this picture as an electronic greeting card at **nationalgeographic.com/ngm/0110.**

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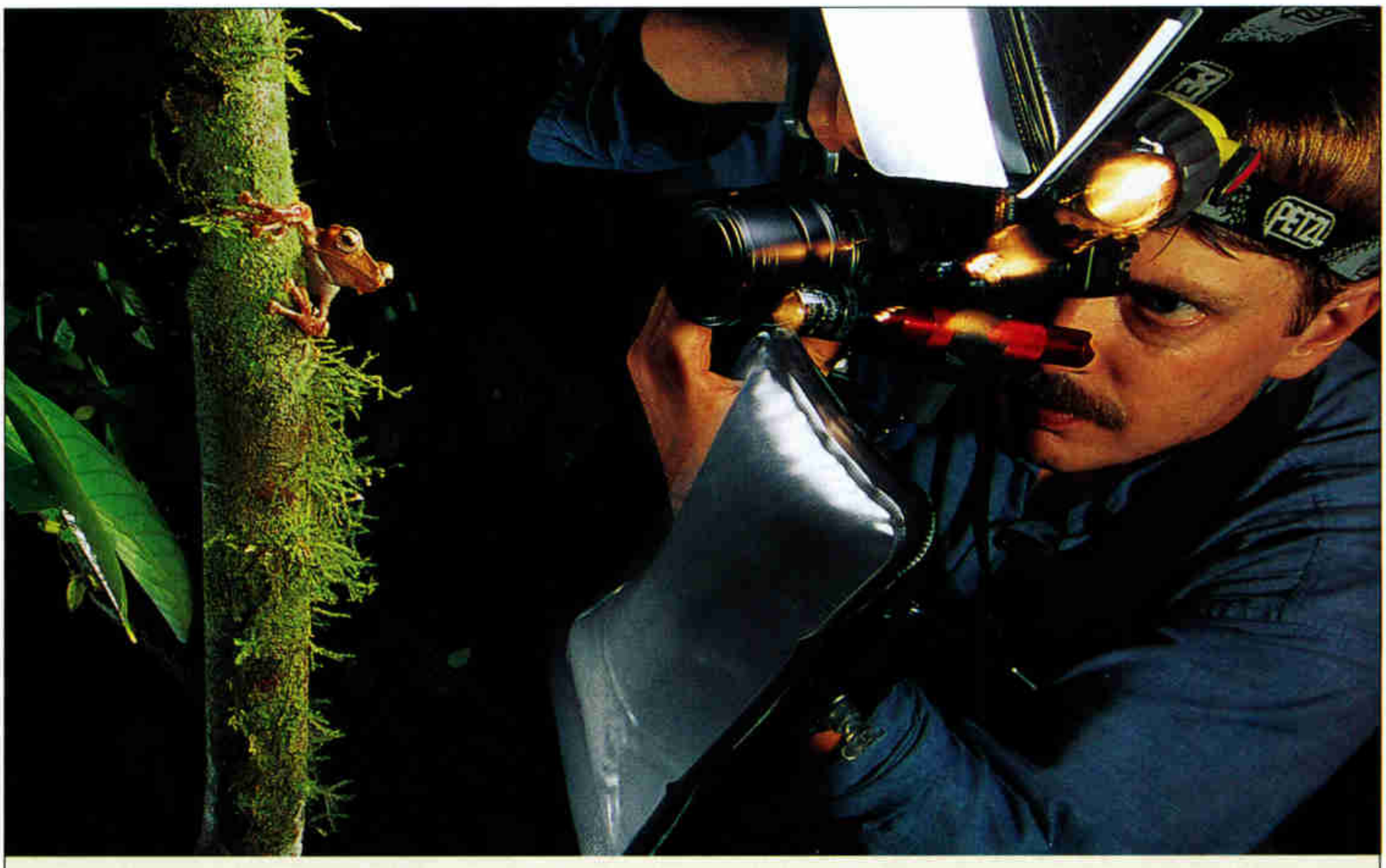
ON THE ROAD, IN THE FIELD,



BORNEO

Home, Sweet Forest

The nightlife is jumping—and comes to visit

Oblivious to everything else around him in the Borneo rain forest, **Tim Laman** trains his camera and two flashes on a file-eared tree frog (top). It was just one night of many months Tim spent documenting rain forest life. "In the final push I went totally nocturnal for weeks, staying out in the forest until the first hint of dawn," he says.

Sometimes, though, he did not have to go out to do his job; creatures came right to his open-to-the-forest palm-thatched hut. Cicada larvae climbed up the wall of the hut and used it as a place to molt, leaving their skins behind (left) when they emerged as adults. And a giant huntsman spider captured a large praying mantis and enjoyed its dinner on a house beam (below) as Tim prepared his own meal.

ALL BY TIM LAMAN; JAMES W. ANNESS (FACING PAGE)

GNMENT

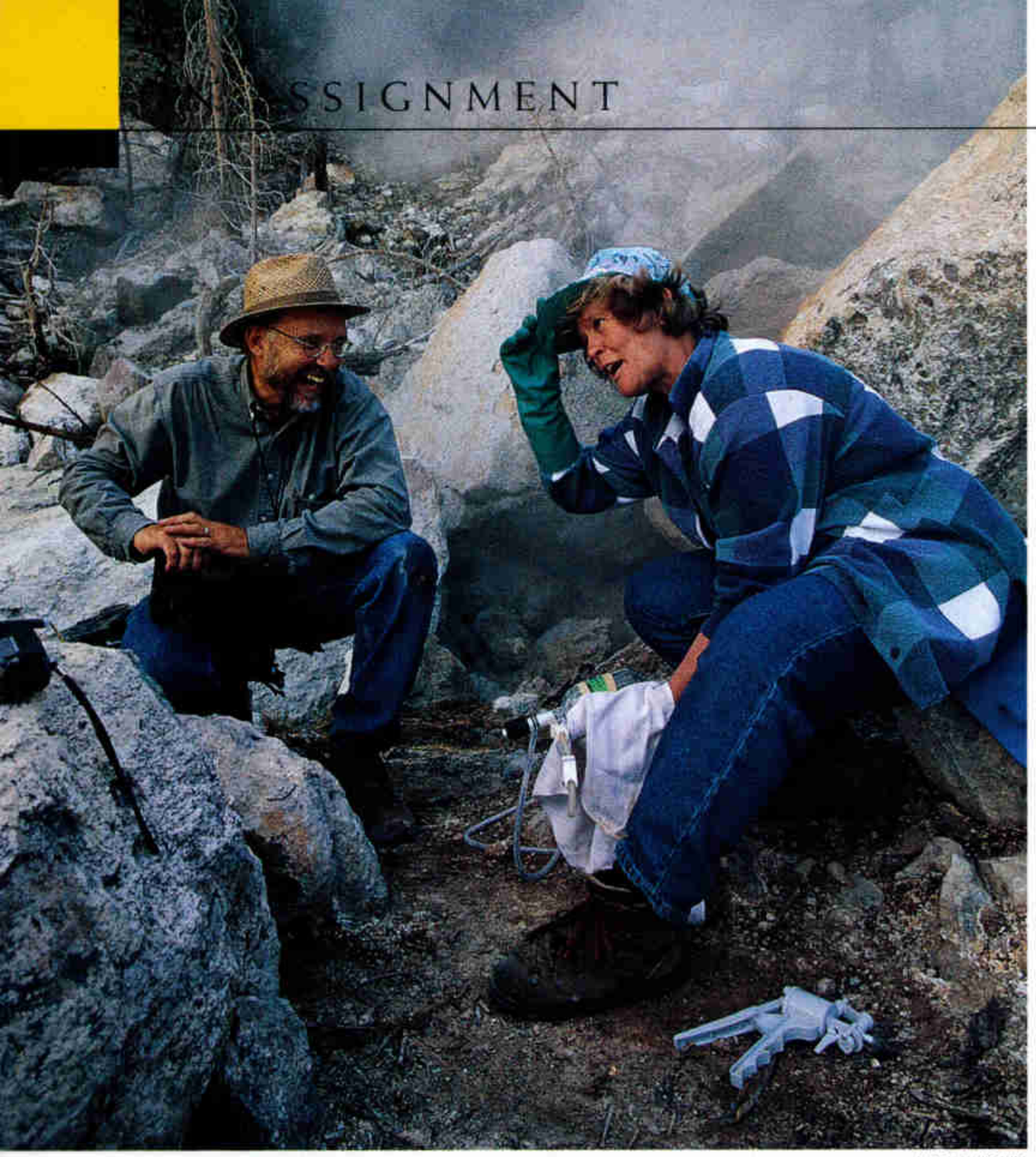
COVERING THE WORLD

NEW YORK CITY

Some View!

But look where you have to go to appreciate it

Dangling 1,450 feet up in a howling wind on the antenna of the Empire State Building, **Joe McNally,** second from top, photographs "the ultimate lightbulb-changing job" for the "Power of Light" article. What gear did Joe pack? "Two cameras, a couple of lenses—you don't want to drag a lot of stuff up there—and my nerve." On the descent his hand cramped on a climbing peg, and he had to pry it off. "But it's a great view," he adds. "It's why I got into this field in the first place, to do stuff very few people get to do."



MARK HUEBNER

CALIFORNIA

In the Hot Seat

Working on a volcano is playing with fire

Hydrothermal areas call for a cool head, warns photographer **Jim Richardson,** here exploring Devils Kitchen at Lassen Volcanic National Park with geochemist Cathy Janik. "If you aren't vigilant, you can sit down on a fumarole that burns a hole in your backside," Jim says. "This landscape wasn't built for people and OSHA safety rules." Acidity can burn the coating off lenses. "You weigh how valuable a picture is. In some cases ruining a lens is worth it: You don't want to come down without the picture you went up to get."

WORLDWIDE

It was to be expected that **Kim Wolhuter** became a game park manager in Africa: His grandfather was the first game ranger in South Africa's Kruger National Park, and his father was a ranger too. The surprise was that Kim switched to photography. He spent 19 months tracking the same male leopard to produce this month's cover story. "After a time the leopard realized that we weren't doing any harm," says Kim. "Once you get an animal so relaxed, any behavior he shows is totally natural."

Linda Gómez grew up in a Spanish family in California and lived in Puerto Rico for seven months. Though she had not been to Adjuntas, "I had a constant feeling of having been there before," she says. "I'd smell an aroma, and it would take me back to my aunt's kitchen." After college and prior to joining the staff of *Life* magazine, Linda served a stint as a New York waitress. " 'Phi Beta Kappa waitress,' my father called me. He wasn't happy about my career choice then."

O. LOUIS MAZZATENTA

Chinese archaeologist Duan Qingbo and author **Peter Hessler** (right, at left) compare notes on a surprisingly muscular statue Duan jokingly calls Mike Tyson. Peter, who writes about the ancient Chinese treasures in his first GEOGRAPHIC article, "Rising to Life," is a former Rhodes scholar and Peace Corps volunteer who spent two years as an instructor at a teachers college in the Yangtze River city of Fuling. He wrote about the experience in a book, *River Town.* Photographer **Lou Mazzatenta** has been to China about a dozen times on assignment since 1990 and has built up excellent working relationships. "I'm known there," he observes, "but they have difficulty saying Mazzatenta. It's hard to pronounce. So my friends call me Lao Ma, which means 'Old Mr. Horse.' " Lou served on the magazine staff for 32 years until retiring in 1994 to freelance.

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Example of "Wet" Sprinkler

Example of "Dry" Sprinkler

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Flashback

OSRAM SYLVANIA

THE POWER OF LIGHT

Bright Idea

The Cairo night was chased—for a moment—by the light of 6,500 flashbulbs on May 24, 1959. The illumination of the Great Pyramid of Khufu, part of a promotional event by the bulb manufacturer, Sylvania, was triggered with a series of synchronized circuits strung along 14 miles of wire. Preparations for the shot took more than a month; a team of 20 men made two sides of the ancient structure bristle with flashlamps attached to four-foot poles wedged between the limestone blocks.

This photograph was never before published in the magazine.

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You can send this month's Flashback as an electronic greeting card and access the Flashback photo archives at **nationalgeographic.com/ngm/flashback/0110.**

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